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Food Processing and Technology 1982: A Summary of Research

The Ohio State University
Ohio Agricultural Research and Development Center
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Evaluation of Tomato Cultivars for Processing

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INTRODUCTION

In Ohio tomatoes continue to be an important processing crop, with planted acreage slightly less than 20,000 acres with 400,000 ton production. Ohio ranks second only to California in volume of processed tomatoes, tomato juice, and tomato products.

This study is concerned primarily with evaluating new tomato cultivars vs. standard cultivars for processing. The research is also directed toward improvement of the quality of the various type products packed from tomatoes. The specific objective of the program is to determine the suitability of Ohio grown cultivars, developed in the breeding program, for processing.

MATERIALS AND METHODS

The 1980 and 1981 processing project included 28 cultivars in 1980 and 32 cultivars in 1981 grown in replicated plots under acceptable commercial practices at the OARDC Vegetable Crops Branch near Fremont. Each cultivar was machine harvested using an FMC Western Model with little or no sort on the harvester and bulk handled in 400 lb steel bins. Following harvest, the tomatoes were transported by truck (approximately 100 miles) to The Ohio State University Food Processing Pilot Plant at Columbus for processing. All lots were processed on or before 24 hours hold following harvest as peeled whole tomatoes and juice.

A. Twenty field-run tomatoes were randomly selected and used for objective and subjective raw quality evaluation.

1. The tomatoes were classified as Globe, Pear, Blocky, or Ovate in shape.
2. *Size* was determined by weighing a 20-tomato sample, counting the number of tomatoes, and then calculating the number per pound.
3. Objectively, *stem scar length* and *stylar scar length* were measured by determining the average length in inches of each scar.
4. *Firmness* was determined subjectively and rated as puffy, medium, and hard.
5. The sample was then quartered and extracted using the California Blender system of extraction as follows:

- Remove 8.5 lb of tomatoes sampled at random from lot.
- Wash the 8.5 lb sample, quarter, and stem the fruits.
- Place the sample in a blender and cover with blender lid connected to a vacuum hose.
- Start vacuum and when gauge reaches 27, start blender for 5 seconds.
- Stop the blender, remove the container without breaking vacuum, and turn upside down and shake. Return the container to the blender and blend for 1 minute.
- Remove the blender lid and insert 14 mesh wire screen into container and ladle juice (175 ml) into Agtron color dish.
- Adjust Agtron calibration, if necessary, close drawer of Agtron and read tomato color.

a. The *color* was evaluated with the Agtron E-5 instrument sample cup with the instrument calibrated at 48. The color reading was taken directly and recorded as such.

b. The *juice color* was also presented to the Hunter Color Difference Meter D25 D3A in a standard plastic sample cup and the Hunter TCM value, L, a, and b values were determined and the a/b ratio was calculated.

c. *Percent soluble solids*: An Abbe refractometer was used for direct determination of percent soluble solids. The instrument was standardized with distilled water and all readings were converted to 70° C. (For juice, the refractive index [R] is also given.)

d. *pH:* The pH was determined by the glass electrode method (Beckman Zeromatic pH Meter) using 10 ml of tomato juice diluted with 90 ml of distilled water.

e. *Percent total acid as citric*: The sample used for pH determination was directly titrated using 0.1 normal sodium hydroxide solution to a pH of 8.1. Calculations using the following equation were made:

$$\text{Percent acid} = \frac{(\text{No of ml of 0.1 N NaOH})\ (.0064)}{10 \text{ ml sample}} \times 100$$

f. *Ascorbic acid*: Ten ml aliquots of tomato juice were diluted with 90 ml of 1% meta-

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phosphoric acid and filtered. A 10 ml aliquot of the filtrate was titrated with 0.2% 2, 6-dichlorophenolindophenol indicator solution. Milligrams of vitamin C were determined by the following formula:

$$\text{Dye factor} \times \text{ml of dye} \times 100 = \frac{\text{mg vitamin C}}{\text{100 g}}$$

g. The *sugar/acid ratio (S/A)* was calculated by dividing the percent soluble solids by the percent titratable acid.

h. *Consistency* was measured in seconds by efluxing 150 ml of juice at 70° F through the GOSUC Consistometer standardized at 32 seconds with water and a 5/64 inch precision bore orifice.

B. Preparation and processing of the tomato: All tomatoes were prepared for canning by washing, lye peeling (18% caustic soda and 0.1% Faspeel at 190° F [88° C] for 20 seconds), filling, closing, and processing in a still retort as whole tomatoes. Each lot of whole tomatoes was filled to 10.0-10.5 oz in No. 303 x 406 size fruit enamel tin cans with a 50-grain salt tablet containing 44.5% NaCl, 15% $CaSO_4 \cdot H_2O$, 37% citric acid, and 3.5% $NaHCO_3$ and covered with hot juice (190° F [88° C]) and steam flow closed.

C. Juice was made from each cultivar of tomato by washing, chopping, preheating to 190°-200° F (88°-93° C), extracting using an 0.023 inch screen in a Langsenkamp extractor, high temperature-short time sterilizing (252° F [122° C], 42 seconds), cooling to 200° F (93° C), filling in 303 x 406 enamel cans, adding a 30-grain NaCl salt tablet, closing, inverting and holding for 3 minutes, and spin-cooling to 100° F (38° C) prior to casing and storing.

D. Grades were determined in accordance with the U. S. Standards for Grades of Canned Tomatoes and Tomato Juice.

RESULTS AND DISCUSSION

The actual data for each cultivar by years as presented in Tables 1 and 2 indicate several potential new cultivars that rated extremely high in quality. Cultivars 07814, 07868, 07870, and 07986 were rated the highest both years. In addition, cultivars 07681 and 07886 in 1980 and 079122, 079116, and 08094 in 1981 were rated very high quality after canning.

Generally, color was superior for all cultivars both years, indicating fully mature fruits at harvest. pH, total acid, and soluble solids varied by cultivar, with most of the values in acceptable ranges for the cultivars both years. The sugar/acid ratio of the juice samples was relatively high with corresponding high scores for juice flavor.

TABLE 1.—Tomato Cultivar Evaluations, 1980, OARDC.

Lot No.	1	2	3	4	5
Cultivar Code	**Campbell 37**	**Hunt's 304**	**Campbell CX 793**	**Heinz 2653**	**Heinz 722**
Raw ($\bar{X}$/20 tomatoes)					
Fruit Shape	Globe-Blocky	Ovate	Blocky	Oblate-Blocky	Oblate-Pear
No./lb	3.38	3.7	4.1	2.4	2.15
Stem Scar	¼ - ½ inch	¼ - ½ inch	¼ - ½ inch	¼ - ½ inch	Less than ¼ inch
Stylar Scar	⅛ inch	None	None	None	⅛ inch
Firmness	Hard	Medium	Hard	Hard	Hard
E-5 Pulp Color	32	34	32.5	33.5	31
TCM Color	74.2	73.4	77.3	74.1	77.4
Hunter L	24.9	24.9	23.5	25.1	24.0
a	26.6	25.7	22.5	30.0	27.2
b	11.1	11.5	10.2	11.8	10.9
pH	4.3	4.3	4.3	4.0	4.3
% T.A.	0.35	0.29	0.33	0.28	0.37
% S.S.	4.4	5.2	4.4	4.2	4.4
Vitamin C	17.4	17.7	15.3	19.1	15.0
a/b ratio	2.4	2.2	2.2	2.5	2.5
Canned Tomatoes					
Drained Wt. (20)	17.5	18.5	19.5	17.0	17.0
Wholeness (20)	20.0	19.0	19.0	20.0	20.0
Color (30)	24.0	25.5	30.0	28.5	29.0
Defects (30)	25.0	24.0	28.0	28.0	30.0
Total Score (100)	86.5	87.0	96.5	93.5	97.0
Grade	B	B	A	A	A
pH	4.25	4.35	4.35	4.40	4.30
% T.A.	0.35	0.33	0.36	0.36	0.39
Tomato Juice					
Color (30)	27.0	28.0	29.0	28.0	28.0
Consistency (15)	13.0	13.0	13.0	13.0	13.0
Defects (15)	15.0	15.0	15.0	15.0	15.0
Flavor (40)	34.0	37.0	38.0	37.0	35.5
Total Score (100)	89.0	93.0	94.0	92.5	91.5
Grade	A	A	A	A	A
Agtron	39.5	37.0	38.8	37.0	36.8
GOSUC	46.2	55.2	56.5	45.7	52.4
pH	4.32	4.29	4.38	4.35	4.48
% T.A.	0.31	0.30	0.30	0.29	0.34
% S.S.	4.9	4.9	4.95	5.0	4.55
Sugar/Acid (S.A.)	15.8	16.3	16.5	17.2	13.6

TABLE 1 (Continued).—Tomato Cultivar Evaluation, 1980, OARDC.

Lot No.	6	7	8	9	10
Cultivar Code	**Heinz 727**	**Petro 80**	**Ohio 7663**	**Ohio 7630**	**Ohio 7681**
Raw					
Fruit Shape	Oblate-Blocky	Globe-Blocky	Blocky	Ovate	Globe-Blocky
No./lb	3.4	2.55	3.5	3.90	5.0
Stem Scar	More than ½ inch	Less than ¼ inch	¼ - ½ inch	¼ - ½ inch	¼ - ½ inch
Stylar Scar	None	None	⅛ inch	None	⅛ inch
Firmness	Hard	Hard	Hard	Medium	Medium
E-5 Pulp Color	32	36	32	34	35
TCM Color	73.9	75.8	72.8	75.9	77.5
Hunter L	25.3	24.3	25.3	24.4	23.7
a	29.7	26.4	28.1	26.5	24.1
b	11.7	11.3	11.9	11.0	10.4
pH	4.05	4.0	4.35	4.35	4.5
% T.A.	0.26	0.28	0.34	0.36	0.24
% S.S.	4.5	4.5	4.6	4.8	5.2
Vitamin C	23.1	18.48	16.8	15.6	12.98
a/b	2.5	2.3	2.4	2.4	2.3
Canned Tomatoes					
Drained Wt. (20)	18.0	17.0	16.0	16.5	19.5
Wholeness (20)	19.0	20.0	20.0	19.0	20.0
Color (30)	27.0	28.0	25.5	25.0	28.5
Defects (30)	27.0	28.5	28.0	25.5	28.0
Total Score (100)	91.5	93.5	89.5	86.0	96.0
Grade	A	A	B	B	A
pH	4.3	4.3	4.3	4.3	4.35
T.A.	0.38	0.38	0.35	0.35	0.34
Tomato Juice					
Color (30)	27.5	25.0	29.0	28.0	27.0
Consistency (15)	13.0	13.0	13.0	13.0	13.0
Defects (15)	15.0	15.0	15.0	15.0	15.0
Flavor (40)	30.0	30.0	36.0	38.0	38.0
Total Score (100)	85.5	83.0	93.0	94.0	93.0
Grade	C	C	A	A	A
Agtron	35.8	38.0	35.8	36.0	41.0
GOSUC	43.8	42.7	50.2	45.5	43.8
pH	4.48	4.41	4.40	4.38	4.40
T.A.	0.34	0.28	0.28	0.31	0.29
S.S.	4.7	4.8	4.9	4.9	4.6
S/A	16.8	17.1	16.0	16.9	17.7

TABLE 1 (Continued).—Tomato Cultivar Evaluation, 1980, OARDC.

Lot No.	11	12	13	14	15
Cultivar Code	**Ohio 7814**	**Ohio 7864**	**Ohio 7868**	**Ohio 7869**	**Ohio 7826**
Raw					
Fruit Shape	Blocky	Blocky	Blocky	Globe-Blocky	Blocky
No./lb	2.2	3.1	3.2	3.7	2.4
Stem Scar	¼ - ½ inch	¼ - ½ inch	Less than ¼ inch	¼ - ½ inch	Less than ¼ inch
Stylar Scar	None	None	None	⅛ inch	None
Firmness	Hard	Hard	Hard	Hard	Hard
E-5 Pulp Color	31	31	29	34	31
TCM Color	73.4	73.2	82.7	78.8	76.0
Hunter L	25.4	25.5	22.7	23.7	24.4
a	29.0	29.8	28.3	25.2	28.9
b	11.3	11.5	10.5	9.8	11.7
pH	4.35	4.35	4.4	4.25	4.4
T.A.	0.35	0.29	0.34	0.35	0.31
S.S.	5.6	4.8	4.2	4.4	4.3
Vitamin C	13.6	13.8	16.8	16.2	18.3
a/b	2.6	2.9	2.7	2.6	2.5
Canned Tomatoes					
Drained Weight (20)	18.5	16.0	16.0	16.5	20.0
Wholeness (20)	20.0	20.0	20.0	20.0	20.0
Color (30)	29.0	29.0	25.0	23.5	24.0
Defects (30)	30.0	29.0	26.0	23.0	29.0
Total Score (100)	97.5	94.0	86.0	83.0	93.0
Grade	A	A	B	C	B
pH	4.33	4.25	4.28	4.25	4.30
T.A.	0.42	0.36	0.39	0.36	0.38
Tomato Juice					
Color (30)	28.0	28.0	30.0	29.0	29.0
Consistency (15)	13.0	13.0	13.0	13.0	13.0
Defects (15)	15.0	15.0	15.0	15.0	15.0
Flavor (40)	36.0	38.0	37.0	36.0	30.0
Total Score (100)	92.0	94.0	94.0	93.0	87.0
Grade	A	A	A	A	A
Agtron	35.5	33.8	34.0	35.0	37.0
GOSUC	53.3	58.5	49.3	40.8	49.4
pH	4.35	4.4	4.42	4.35	4.42
T.A.	0.36	0.30	0.31	0.32	0.29
S.S.	5.2	5.0	5.4	5.0	4.8
S/A	14.4	16.7	17.4	15.6	16.6

TABLE 1 (Continued).—Tomato Cultivar Evaluation, 1980, OARDC.

Lot No.	16	17	18	19	20
Cultivar Code	**Ohio 7832**	**Ohio 7843**	**Ohio 7855**	**Ohio 7858**	**Ohio 7870**
Raw					
Fruit Shape	Globe-Blocky	Globe-Blocky	Globe-Blocky	Oblate-Blocky	Globe-Blocky
No./lb	4.1	2.5	2.7	3.0	2.7
Stem Scar	¼ - ½ inch	¼ - ½ inch	¼ - ½ inch	¼ - ½ inch	¼ - ½ inch
Stylar Scar	⅛ inch	None	None	None	None
Firmness	Medium	Hard	Hard	Hard	Hard
E-5 Pulp Color	31	31	33	32	34
TCM Color	78.4	78.3	76.5	74.9	78.9
Hunter L	23.8	24.1	24.3	25.0	23.5
a	27.7	30.1	26.9	29.4	24.8
b	11.0	11.0	10.8	11.5	10.2
pH	4.4	3.95	4.3	4.1	4.4
% T.A.	0.34	0.35	0.31	0.38	0.37
% S.S.	4.4	4.4	5.8	4.6	4.8
Vitamin C	16.8	15.8	14.75	17.2	18.0
a/b	2.5	2.7	2.5	2.6	2.4
Canned Tomatoes					
Drained Wt. (20)	16.0	19.0	16.0	17.0	16.0
Wholeness (20)	18.5	20.0	20.0	20.0	20.0
Color (30)	28.5	30.0	25.0	27.0	28.0
Defects (30)	30.0	30.0	30.0	29.0	30.0
Total Score (100)	93.0	99.0	92.0	96.0	93.0
Grade	A	A	B	A	A
pH	4.28	4.8	4.38	4.35	4.3
T.A.	0.39	0.31	0.36	0.37	0.38
Tomato Juice					
Color (30)	30.0		30.0	28.0	30.0
Consistency (15)	13.0		13.0	13.0	14.0
Defects (15)	15.0		15.0	15.0	15.0
Flavor (40)	39.0		36.0	37.5	38.0
Total Score (100)	97.0		94.0	93.5	97.0
Grade	A		A	A	A
Agtron	36.0		35.0	35.0	35.0
GOSUC	43.2		56.0	51.6	49.4
pH	4.36		4.37	4.41	4.42
T.A.	0.30		0.29	0.29	0.34
S.S.	5.0		5.2	5.4	5.7
S/A	16.7		13.3	18.6	16.6

TABLE 1 (Continued).—Tomato Cultivar Evaluation, 1980, OARDC.

Lot No.	21	22	23	24	25
Cultivar Code	**Ohio 7874**	**Ohio 7893**	**Ohio 7974**	**Ohio 7980**	**Ohio 7986**
Raw					
Fruit Shape	Globe	Globe-Blocky	Oblate-Blocky	Blocky	Globe-Blocky
No./lb	2.8	2.9	3.2	2.9	2.9
Stem Scar	¼ - ½ inch	¼ - ½ inch	More than ½ inch	¼ - ½ inch	¼ - ½ inch
Stylar Scar	⅛ inch	None	None	⅛ inch	None
Firmness	Medium	Hard	Medium	Hard	Hard
E-5 Pulp Color	30.5	31.0	31.0	30.0	30.0
TCM Color	76.8	76.3	77.8	77.3	77.9
Hunter L	24.4	23.9	24.2	24.2	23.9
a	29.6	29.9	29.5	28.2	29.1
b	11.3	10.7	11.1	10.7	11.5
pH	4.05	4.05	4.1	4.3	4.4
% T.A.	0.25	0.37	0.33	0.46	0.29
% S.S.	4.4	4.8	4.8	4.8	4.5
Vitamin C	15.2	17.8	19.8	19.8	16.5
a/b	2.6	2.8	2.7	2.6	2.5
Canned Tomatoes					
Drained Wt. (20)	16.5	18.0	18.0	16.0	16.5
Wholeness (20)	20.0	20.0	20.0	19.5	20.0
Color (30)	28.0	29.5	28.0	30.0	30.0
Defects (30)	28.0	30.0	28.0	29.5	30.0
Total Score (100)	92.5	97.5	94.0	95.0	96.5
Grade	A	A	A	A	A
pH	4.53	4.3	4.33	4.23	4.3
T.A.	0.33	0.4	0.4	0.4	0.39
Tomato Juice					
Color (30)	28.5	29.0	26.0	29.0	29.0
Consistency (15)	13.0	13.0	13.0	13.0	13.0
Defects (15)	15.0	15.0	15.0	15.0	15.0
Flavor (40)	36.0	38.0	38.0	38.0	38.0
Total Score (100)	92.5	95.0	92.0	95.0	95.0
Grade	A	A	A	A	A
Agtron	35.3	33.8	36.3	34.8	33.5
GOSUC	58.7	45.6	50.8	53.2	52.9
pH	4.41	4.35	4.33	4.36	4.44
T.A.	0.35	0.34	0.31	0.35	0.28
S.S.	5.5	5.0	5.4	5.0	5.0
S/A	15.7	14.7	17.4	14.3	17.9

TABLE 1 (Continued).—Tomato Cultivar Evaluation, 1980, OARDC.

Lot No.	26	27	28
Cultivar Code	**Ohio 79138**	**Ohio 79165**	**Ohio 79171**
Raw			
Fruit Shape	Globe-Blocky	Blocky	Globe-Blocky
No./lb	3.1	2.4	2.5
Stem Scar	More than ½ inch	Less than ¼ inch	¼ - ½ inch
Stylar Scar	None	None	None
Firmness	Hard	Hard	Hard
E-5 Pulp Color	30	32	30
TCM Color	77.2	74.3	75.8
Hunter L	24.5	25.2	24.6
a	30.1	27.1	29.7
b	11.3	10.3	11.6
pH	3.95	4.3	4.35
% T.A.	0.30	0.41	0.33
% S.S.	4.1	5.0	4.5
Vitamin C	19.1	13.0	14.2
a/b	2.7	2.6	2.6
Canned Tomatoes			
Drained Wt. (20)	16.0	16.5	18.0
Wholeness (20)	19.0	20.0	20.0
Color (30)	28.0	27.0	28.5
Defects (30)	30.0	25.0	30.0
Total Score (100)	94.0	93.5	96.5
Grade	A	B	A
pH	4.33	4.3	4.3
T.A.	0.39	0.41	0.38
Tomato Juice			
Color (30)	29.0	30.0	29.0
Consistency (15)	13.0	13.0	13.0
Defects (15)	15.0	15.0	15.0
Flavor (40)	40.0	38.0	37.0
Total Score (100)	97.0	96.0	94.0
Grade	A	A	A
Agtron	35.0	36.0	34.0
GOSUC	57.1	51.3	64.3
pH	4.35	4.33	4.38
T.A.	0.32	0.36	0.32
S.S.	5.2	5.2	5.1
S/A	16.3	14.4	16.2

TABLE 2.—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1981.

Lot No.	1	2	3	4
Cultivar Code	**VF 134-1-2**	**Campbell 37**	**Campbell 4135**	**Heinz 722**
Raw				
Fruit Shape	Globe	Blocky	Ovate	Ovate
No./lb	5	4-5	5-6	6-7
Stem Scar	More than ½ inch	¼-½ inch	¼-½ inch	Less than ¼ inch
Stylar Scar	None	⅛ inch	⅛ inch	None
Firmness	Medium	Medium	Medium	Hard
E-5 Pulp Color	35	37.5	35	34
L	26.3	27.0	25.5	26.5
a	30.0	28.5	29.7	31.2
b	11.3	11.4	11.3	11.4
a/b	2.66	2.49	2.63	2.73
TCM	71.2	69.0	73.3	70.8
pH	4.4	4.4	4.45	4.39
T.A.	0.45	0.29	0.46	0.39
S.S.	4.6	4.7	4.8	4.7
Canned				
Drained Wt. (20)	17	16	16	16
Wholeness (20)	20	20	20	20
Color (30)	28	28	28	26.5
Defects (30)	30	30	28	30
Total Score (100)	95	94	92	92.5
Grade	A	A	A	A
Juice				
pH	4.4	4.5	4.6	4.6
T.A.	0.34	0.29	0.27	0.35
S.S.	5.4	5.6	5.1	5.3
Sugar/Acid	16	19	19	15
E-5	34.5	36	36	35.3
a/b	2.2	2.14	2.1	2.25
TCM	73.1	71.7	71.8	72.5
Tube Vis. (GOSUC)	63	65	61	87
Color (30)	30	28	28	30
Consistency (15)	13	13	13	13
Defects (15)	15	15	15	15
Flavor (40)	38	38	38	38
Total Score (100)	96	94	94	96
Grade	A	A	A	A

TABLE 2 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1981.

Lot No.	5	6	7	9
Cultivar Code	**Heinz 2653**	**Castle Hy 1508**	**Castle Hy 1509**	**Castle X1619**
Raw				
Fruit Shape	Ovate	Globe	Blocky	Globe
No./lb	6-7	5-6	4-5	4-5
Stem Scar	Less than ¼ inch	Less than ¼ inch	¼ - ½ inch	¼ - ½ inch
Stylar Scar	None	None	⅛ inch	⅛ inch
Firmness	Medium	Hard	Medium	Medium
E-5 Pulp Color	34	34	39	43
L	26.4	25.5	25.3	24.3
a	27.6	27.4	24.8	22.6
b	11.5	11.4	10.6	9.8
a/b	2.5	2.4	2.33	2.3
TCM	70.3	72.5	72.7	75.6
pH	4.4	4.6	4.4	4.5
T.A.	0.34	0.21	0.26	0.28
S.S.	4.2	4.6	4.4	4.4
Canned				
Drained Wt. (20)	16	16	16	16
Wholeness (20)	20	20	20	20
Color (30)	25.5	30	25	27.5
Defects (30)	30	28	30	29
Total Score (100)	91.5	94	91	92.5
Grade	B	A	B	B
Juice				
pH	4.5	4.6	4.4	4.5
T.A.	0.34	0.21	0.28	0.31
S.S.	5.5	5.7	5.2	5.5
Sugar/Acid	16	27	19	18
E-5	36.8	33.8	35.8	36.5
a/b	2.14	2.23	2.16	2.16
TCM	70.6	74.0	73.3	70.5
Tube Vis. (GOSUC)	50	66	55	70
Color (30)	28	28	28	28
Consistency (15)	13	13	13	13
Defects (15)	15	15	15	15
Flavor (40)	35	36	38	40
Total Score (100)	91	92	94	96
Grade	A	A	A	A

TABLE 2 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1981.

Lot No.	10	11	12	13	14
Cultivar Code	**Ferry Morse E6203**	**US 68**	**Peto Hy 31**	**Peto 95**	**Purdue 80 A04**
Raw					
Fruit Shape	Ovate	Ovate	Globe	Blocky	Ovate
No./lb	4-5	5-6	5-6	5	5
Stem Scar	¼ - ½ inch	¼ - ½ inch	¼ - ½ inch	¼ - ½ inch	¼ - ½ inch
Stylar Scar	⅛ inch	None	None	None	None
Firmness	Medium	Hard	Medium	Hard	Medium
E-5 Pulp Color	34	34	37	37	33
L	26.2	25.7	25.3	24.3	24.5
a	30.2	29.0	25.4	25.3	29.1
b	11.3	11.1	10.6	10.9	11.6
a/b	2.67	2.62	2.4	2.32	2.51
TCM	71.5	72.8	72.9	75.7	75.9
pH	4.5	4.34	4.4	4.4	4.5
T.A.	0.38	0.34	0.39	0.32	0.33
S.S.	5.2	5.0	4.8	5.0	4.8
Canned					
Drained Wt. (20)		17	16	16	16
Wholeness (20)		20	20	20	20
Color (30)		27.5	27	28	30
Defects (30)		30	30	30	28
Total Score (100)		94.5	93	94	94
Grade		A	A	A	A
Juice					
pH	4.6	4.4	4.5	4.5	4.5
T.A.	0.33	0.34	0.39	0.30	0.33
S.S.	5.8	5.5	5.7	6.2	6.4
Sugar/Acid	17	16	15	21	20
E-5	39.5	36.5	36.3	35.5	38
a/b	2.04	2.14	2.11	2.2	2.1
TCM	68.6	70.5	70.5	71.9	75.1
Tube Vis. (GOSUC)	82	72	51	77	51
Color (30)	28	28	28	29	30
Consistency (15)	13	13	13	13	13
Defects (15)	15	15	15	15	15
Flavor (40)	35	36	33	35	35
Total Score (100)	91	92	89	92	93
Grade	A	A	A	A	A

TABLE 2 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1981.

Lot No.	15	16	17	18	19
Cultivar Code	**Ohio 7814**	**Ohio 7864**	**Ohio 7868**	**Ohio 7870**	**Ohio 7855**
Raw					
Fruit Shape	Ovate	Ovate	Ovate	Ovate	Globe
No./lb	7-8	4-5		5-6	5-6
Stem Scar	¼ - ½ inch	¼ - ½ inch	¼ - ½ inch	Less than ¼ inch	Less than ¼ inch
Stylar Scar	None	⅛ inch	None	None	None
Firmness	Hard	Hard	Hard	Hard	Hard
E-5 Pulp Color	33	33	32	33	33
L	26.2	25.9	24.3	24.4	25.3
a	29.7	30.6	27.9	30.2	25.7
b	11.5	11.6	10.4	10.6	10.8
a/b	2.57	2.64	2.69	2.85	2.37
TCM	70.6	72.2	77.2	77.5	72.8
pH	4.3	4.4	4.4	4.5	4.5
T.A.	0.44	0.37	0.38	0.33	0.43
S.S.	5.0	5.0	5.0	5.0	4.5
Canned					
Drained Wt. (20)	18	18	16	16.5	16
Wholeness (20)	20	20	20	20	20
Color (30)	30	29	27.5	29.3	28.5
Defects (30)	30	28	30	30	30
Total Score (100)	98	95	93.5	95.8	94.5
Grade	A	A	A	A	A
Juice					
pH	4.5	4.6	4.5	4.5	4.6
T.A.	0.46	0.28	0.38	0.32	0.31
S.S.	6.2	5.4	6.2	5.6	5.8
Sugar/Acid	14	19	16	18	18
E-5	37	37	35	39	34.8
a/b	2.17	2.12	2.44	1.94	2.19
TCM	71.9	74.5	77.2	74.4	74.0
Tube Vis. (GOSUC)	143	105	94	50	59
Color (30)	28	28	30	30	30
Consistency (15)	13	13	13	14	13
Defects (15)	15	15	15	15	15
Flavor (40)	35	38	35	39	40
Total Score (100)	91	94	93	98	98
Grade	A	A	A	A	A

TABLE 2 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1981.

Lot No.	20	21	22	23	24
Cultivar Code	**Ohio 7874**	**O 7916 94**	**O 7916 96**	**O 7955**	**O 7974**
Raw					
Fruit Shape	Globe	Ovate	Ovate	Ovate	Globe
No./lb	5-6	5-6	4-5	6-7	5-6
Stem Scar	¼ - ½ inch	Less than ¼ inch	¼ - ½ inch	Less than ¼ inch	¼ - ½ inch
Stylar Scar	⅛ inch	None	None	None	None
Firmness	Medium	Hard	Hard	Medium	Medium
E-5 Pulp Color	35	31.5	33	34	38
L	26.1	24.3	23.6	25.5	27.4
a	26.7	30.6	29.4	28.9	26.7
b	10.7	10.7	10.7	11.0	10.6
a/b	2.49	2.85	2.75	2.62	2.5
TCM	71.3	77.7	79.8	73.2	67.8
pH	4.4	4.4	4.5	4.4	4.3
T.A.	0.40	0.31	0.26	0.38	0.33
S.S.	5.0	5.2	5.0	5.8	5.6
Canned					
Drained Wt. (20)	17	16	16	17	16
Wholeness (20)	20	20	20	19	20
Color (30)	29	29.5	29	30	22
Defects (30)	30	30	30	28	27
Total Score (100)	96	95.5	95	94	85
Grade	A	A	A	A	C
Juice					
pH	4.5	4.5	4.6	4.6	4.5
T.A.	0.35	0.28	0.29	0.35	0.37
S.S.	5.7	5.8	6.0	5.4	6.0
Sugar/Acid	16	21	21	15	16
E-5	35	34.3	34	35	35.3
a/b	2.11	2.27	2.29	2.32	2.41
TCM	70.9	75.4	76.3	73.1	71.3
Tube Vis. (GOSUC)	83	78	58	76	65
Color (30)	28	30	30	30	30
Consistency (15)	13	13	13	13	14
Defects (15)	15	15	15	15	15
Flavor (40)	35	38	40	38	35
Total Score (100)	91	96	98	96	94
Grade	A	A	A	A	A

TABLE 2 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1981.

Lot No.	25	26	27	28
Cultivar Code	**0 7980**	**0 7981**	**0 7986**	**0 79116**
Raw				
Fruit Shape	Pear	Ovate	Ovate	Ovate
No./lb	5-6	6-7	5-6	7-8
Stem Scar	Less than ¼ inch	Less than ¼ inch	¼-½ inch	Less than ¼ inch
Stylar Scar	None	None	None	None
Firmness	Medium	Puffy	Hard	Medium
E-5 Pulp Color	36	37	34	34
L	25.7	26.2	26.9	23.6
a	26.4	28.9	31.7	30.2
b	10.6	11.0	11.1	10.5
a/b	2.49	2.61	2.85	2.86
TCM	72.2	70.5	70.3	80.0
pH	4.4	4.3	4.4	4.5
T.A.	0.38	0.33	0.35	0.35
S.S.	5.0	4.9	5.0	5.0
Canned				
Drained Wt. (20)	18	17	16	17
Wholeness (20)	20	20	20	20
Color (30)	28	24	29	30
Defects (30)	28	28	30	30
Total Score (100)	94	89	95	97
Grade	A	B	A	A
Juice				
pH	4.5	4.5	4.4	4.6
T.A.	0.35	0.34	0.32	0.33
S.S.	5.8	5.5	5.8	5.8
Sugar/Acid	17	16	18	18
E-5	35.5	36	35	32.8
a/b	2.2	2.18	2.21	2.4
TCM	72.0	71.7	75.0	76.4
Tube Vis. (GOSUC)	75	59	40	106
Color (30)	28	27	30	30
Consistency (15)	13	13	13	13
Defects (15)	15	15	15	15
Flavor (40)	35	38	38	40
Total Score (100)	91	93	96	98
Grade	A	A	A	A

TABLE 2 (Continued).—Tomato Cultivar Evaluation, Raw Product, Canned Whole Pack, and Juice, 1981.

Lot No.	29	30	31	32
Cultivar Code	**0 79122**	**0 8038**	**0 8094**	**0 8095**
Raw				
Fruit Shape	Ovate	Ovate	Globe	Globe
No./lb	4-5	5	6-7	4-5
Stem Scar	¼ - ½ inch	¼ - ½ inch	¼ - ½ inch	More than ½ inch
Stylar Scar	⅛ inch	None	None	⅛ inch
Firmness	Hard	Medium	Hard	Hard
E-5 Pulp Color	32	37	35	35
L	23.8	29.6	23.7	26.1
a	28.8	31.6	28.6	29.0
b	10.6	12.6	10.8	10.7
a/b	2.72	2.51	2.64	2.71
TCM	78.9	63.0	78.9	72.1
pH	4.5	4.3	4.5	4.3
T.A.	0.31	0.37	0.28	0.36
S.S.	4.7	4.6	4.9	5.1
Canned				
Drained Wt. (20)	18	17	18	16
Wholeness (20)	20	20	20	20
Color (30)	29	26.5	29.5	25
Defects (30)	30	30	30	29
Total Score (100)	97	93.5	97.5	90
Grade	A	B	A	B
Juice				
pH	4.6	4.5	4.5	4.6
T.A.	0.25	0.37	0.31	0.31
S.S.	5.8	5.6	6.0	5.6
Sugar/Acid	23	15	19	18
E-5	34	35.5	36	35
a/b	2.32	2.24	2.23	2.26
TCM	77.5	73.9	74.4	74.3
Tube Vis. (GOSUC)	55	62	94	59
Color (30)	30	29	30	30
Consistency (15)	13	15	15	13
Defects (15)	15	15	15	15
Flavor (40)	40	38	38	38
Total Score (100)	98	97	98	96
Grade	A	A	A	A

Raw Tomato Color Evaluation

WILBUR A. GOULD[1]

INTRODUCTION

The color of tomatoes is a major characteristic of raw product evaluation for grade. Color has been evaluated subjectively by the grader in the past with acceptable results. In the late 1950's, color was objectively evaluated using several instruments. An outgrowth of this work was the adoption of the Hunter Tomato Color Meter and a Tomato Color Index (TCI) to predict the color of the load of tomatoes. Thus, a TCI index was established:

$$TCI = \frac{a}{L} \times \frac{1}{(a^2 + b^2)\ 1/2} \times 2000$$

where:

L = lightness (Hunter L)

a = redness (Hunter a)

b = greenness (Hunter b)

In the TCI formula, "L" values are used in the calculation and rightly so as tomatoes in the 1960's had a lot of white core and the "L" value reflected this fact. However, new cultivars have little or no white core and thus no need for the "L" value. California adopted the AGTRON system in the 1960's in contrast to the use of the Hunter Tomato Color Meter in other sections of the country where tomatoes are processed. The AGTRON instrument is a more rugged instrument and has a built-in color standard. Further, it was designed to read the red:green ratio as one would expect to find in tomatoes of varying maturities.

In addition to the color measurement system, the USDA color preparation method used an extractor (Berkel Co.) that worked on a principle similar to commercial juice extraction. However, parts of this equipment are no longer available. California adopted a blender system of extraction (Waring Blender at controlled speeds and for given times) under vacuum and used a larger screen to screen out the seeds and defective pieces when taking the sample for color readings.

MATERIALS AND METHODS

A maximum of 195 commercial loads of tomatoes were sampled by taking two to four 40 lb cores from each load as delivered to three different factories in Ohio. Each sample was divided by the USDA-ODA inspector into two lots. One lot was extracted by the inspector for color inspection (A), the other half was further divided with one-half extracted using the Berkel system and color extracted (B), the other half extracted and color evaluated (CO). Color was determined for all the lots using the AGTRON E5-F, the Hunter Color and Color Difference Meter and calculating the a/b ratio, and the Tomato Color Index from the USDA Colorimeter.

RESULTS AND DISCUSSION

Figure 1 shows the detailed breakdown of the separation procedures and extraction methods. The correlation values and the calculated regression lines from the data are presented in Table 1. The AGTRON and Hunter a/b ratios correlated the best, although all values were highly significant.

The data in Table 2 give the color values (average, standard deviation, and coefficient of variability) for the Tomato Color Index, AGTRON, and the Hunter a/b ratio by the two extraction methods. These data clearly show a difference in using the two extraction procedures when reading the color or TCI (71.4 for Berkel vs. 74.7 for California), while AGTRON values were similar with a slight difference for a/b ratios.

The data in Table 3 show a further breakdown of the extraction methods for the various color values

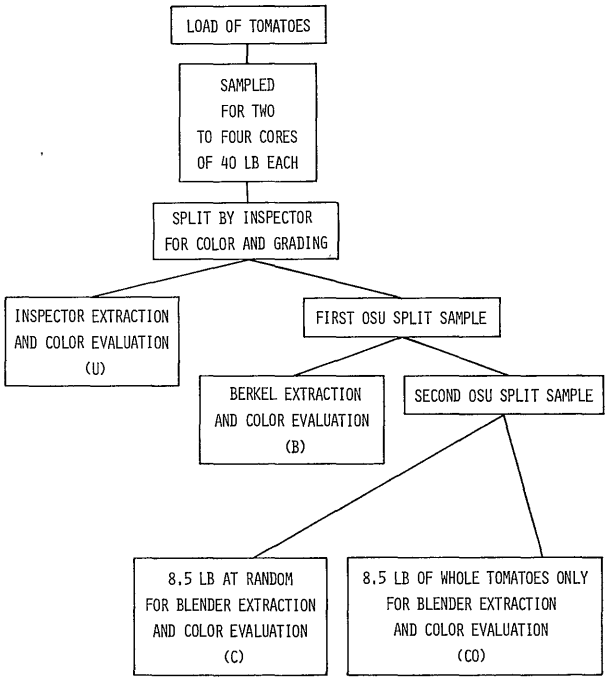

FIG. 1.—Sample and extraction procedure.

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TABLE 1.—Color Correlation Values (r) and the Calculated Regression Line (Y = aX + b) by Extraction System.

X	Y	r	n	Y = aX + b
Berkel System (B)				
a/b	Ag — OSU	—0.672	195	Y = 18.5X + 82.9
a/b	TC — OSU	0.379	195	Y = 5.99X + 57.4
TC — OSU	Ag — OSU	—0.254	195	Y = —0.439X + 71.7
California — Blender System (C)				
a/b	Ag — OSU	—0.804	193	Y = —20.2X + 85.2
a/b	TC — OSU	0.438	193	Y = 6.79X + 59.5
TC — OSU	Ag — OSU	—0.302	193	Y = —0.491X + 76.7
California Ohio System (CO)				
a/b	Ag — OSU	—0.754	81	Y = —14.1X + 70.3
a/b	TC — OSU	0.540	81	Y = 7.94X + 55.3
TC — OSU	Ag — OSU	—0.459	81	Y = —0.586X + 81.6
Official USDA System (U)				
a/b	Ag — OSU	—0.651	148	Y = —12.2X + 67.1
a/b	TC — OSU	0.296	151	Y = 4.08X + 62.5
TC — OSU	Ag — OSU	—0.310	148	Y = —0.421X + 68.3

Note: All r values are highly significant (0.01 % level).
a/b=Hunter a value divided by Hunter b value
n=Number of loads
Ag=AGTRON
TC=Tomato Color Index

at each of the receiving stations. The differences at the stations are due to quality of loads and generally the color data agree well except for the California system of extraction. Here color values are improved, indicating less green if previously extracted with the California system.

From these and other data, Figures 2 and 3 were constructed to show the relationship of TCI and a/b values to tomato color (Fig. 2) and relationship of AGTRON Color Values to tomato color (Fig. 3).

TABLE 2.—Color Evaluation by Extraction Methods (Average for 196 Loads).

Color Method	Values*	Extraction Methods: Berkel	Extraction Methods: California
TCI	Av	71.04	74.7
	s	3.35	3.56
	CV	4.72	4.6
AGTRON	Av	40.57	40.42
	s	4.48	5.57
	CV	11.04	13.9
A/B	Av	2.30	2.24
	s	0.20	0.22
	CV	8.7	9.8

*Av—Average Values
s—Standard Deviation
CV—Coefficient of Variability

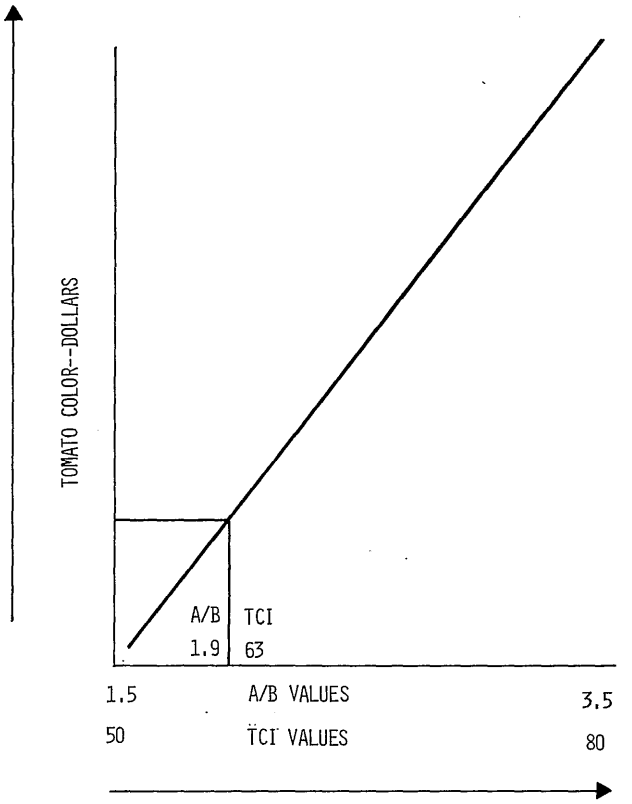

FIG. 2.—Relationship of TCI and a/b values to tomato color.

TABLE 3.—Color Evaluation by Extraction Methods at Three Grading Stations.

Extraction	Station	TCI			AGTRON			A/B		
		N	Av	s	N	Av	s	N	Av	s
U	A	71	73.28	2.70	69	38.72	4.35	71	2.38	0.25
	B	47	72.15	2.31	47	36.26	2.13	47	2.45	0.13
	C	25	70.24	2.05	25	36.92	1.77	25	2.26	0.22
	Av		71.89			37.30			2.36	
B	A	71	71.15	3.09	69	41.28	6.43	71	2.27	0.22
	B	47	71.06	2.44	47	39.79	4.67	47	2.35	0.22
	C	25	69.48	2.17	25	38.39	2.38	25	2.99	0.68
	Av		70.50			39.82			2.54	
C	A	71	74.00	3.53	69	42.90	6.59	71	2.14	0.24
	B	47	74.11	2.65	47	37.43	3.93	47	2.30	0.19
	C	25	75.36	2.33	25	37.22	3.32	25	2.78	0.36
	Av		74.49			39.18			2.41	
CO	A	71	73.00	3.08	69	38.74	3.89	71	2.22	0.20

Note: U—USDA System
B—Berkel System
C—California System
CO—California Ohio System

All data were statistically analyzed with regression line calculated as shown in Table 1.

CONCLUSIONS

1) Change to the California Blender system of extraction as follows:

- Take 8.5 lb of tomatoes in conjunction with 50 lb inspection sample.
- Wash the 8.5 subsample and stem the fruits.
- Place the subsample in a blender and cover with blender lid connected to vacuum hose.
- Start vacuum and when gauge reaches 27, start blender for 5 seconds.
- Stop blender, remove container without breaking vacuum, and turn upside down and shake. Return container to blender and blend for 1 minute.
- Remove lid and insert 14-mesh wire screen into container and ladle 175 ml into AGTRON color dish.
- Adjust AGTRON calibration, if necessary, close drawer of AGTRON, and read and record tomato color.

2) Adopt the AGTRON system for color evaluation using an AGTRON E-5 Colorimeter with 43 as the cut-off value; *i.e.,* loads exceeding 44 do not meet the TCI 63 value.

RECOMMENDATION

Tomatoes that are cut by the sampler should not be used for color evaluation. Further, tomatoes that are defective should not be used as dark areas (rot, mold) will negatively influence the actual color value of the sample. Tomatoes for color determination should be taken from the end of the grading belt after they have been washed and the defective fruits are removed. Thus, a defective tomato would only be scored once from a load and neither the grower nor the processor would be penalized twice.

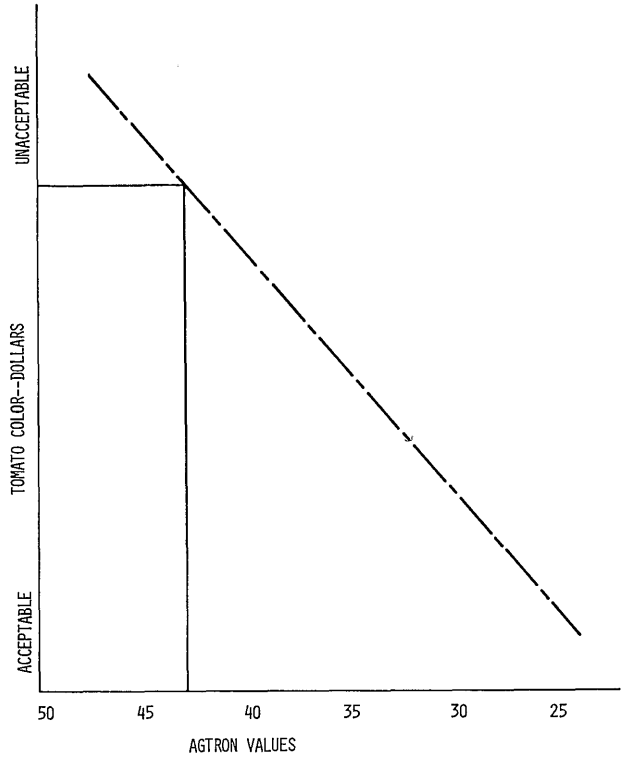

FIG. 3.—Relationship of AGTRON color values to tomato color.

Suitability of 16 Ohio-Grown Tomato Cultivars for Acidified Bulk Storage

R. M. BASEL[1]

ABSTRACT

Sixteen Ohio-grown tomato cultivars were held in acidified bulk storage to determine the influence of cultivar on selected quality attributes. It was found that great differences occurred in quality. Although growing season and cultural practices may greatly affect specific cultivar quality, it was found that 'US 141', 'VF 134-1-2', 'USDA 77B68F1' and 'Heinz 414' gave the best overall quality in this experiment. This study demonstrates that proper cultivar selection is one of the most important criteria for successful acidified bulk storage.

INTRODUCTION

Acidified bulk storage of tomatoes has been suggested as a possible way to lengthen the processing season beyond the normal harvest season (1). The principle of acidified bulk storage is to inactivate enzymes and inhibit microorganisms by sufficiently lowering pH and excluding oxygen. In normal whole tomato production, the tomato cultivar used affects the tomato quality (2). An earlier study found that whole tomatoes could be stored by this method and later processed into whatever processed commodity is needed. The purpose of this study was to determine the suitability of Ohio-grown cultivars for processing.

MATERIALS AND METHODS

The processing tomato cultivars 'Chico III', 'C 37', 'VF 134-1-2', Heinz 414', 'Heinz 2567', 'Heinz 2653', 'Heinz 2867', 'USDA 77B68F1', 'US 28', 'US 141', 'ONT 744', 'ONT 777', 'Kagome 5', '0781383', '07825', and '07858' were used in this study. The above cultivars were grown in replicated plots under acceptable commercial practices at the OARDC Vegetable Crops Branch near Fremont. Each cultivar was machine harvested (with the aid of FMC Western model) with little or no sort on the harvester and bulk handled. Following harvest, the tomatoes were transported by truck (approximately 100 miles) to the Food Processing Pilot Plant at The Ohio State University, Columbus, for processing. All lots were processed following 24-hour hold after harvest.

Whole red ripe tomatoes were selected, washed, and dipped in 100 ppm hypochlorite for 1 minute before storage. Tomato juice used as the cover solution for acidified bulk storage was prepared as described by Gould *et al.* (3) through the pasteurization step and acidified at the rate of 22 ml conc. HCl/liter of juice. In order to store the tomatoes, 680 g of raw tomatoes and 680 g of acidified tomato juice were added to a 3.5 mil 30 x 40 cm polyethylene bag, and vacuum heat sealed with a Griswold Type VNP Vac-U-Seal Machine (Cheslam Corp., Yonkers, NY). Containers were placed inside another bag to limit oxygen diffusion. Acidified stored tomatoes were stored in triplicate at room temperature for 1, 2, and 3 months. All samples from a given replicate were graded and analyzed within a period of 2 days.

Whole tomatoes were canned in 303 containers and graded according to the method of Gould *et al.* (3) for comparison.

Subjective evaluations of acidified stored tomatoes were based upon the following scales of which the five scores represent the good range for normally processed product. This scale was constructed to test the acidified bulk storage techniques and is not analogous to USDA grade. The scales were 0-30 for color, 0-20 for flavor, 0-15 for defects, 0-20 for texture, and 0-20 for overall appearance. The highest score correlated to the best product, whereas a low score indicated a lower quality product.

The percent soft fruit was also measured, calculating the percentage of tomatoes found to have severe softening as determined by touch. This attribute does not necessarily reflect wholeness since very soft tomatoes may still appear whole after storage. Color of whole tomatoes was taken using blended pulp deaerated while being blended at 686 mm of Hg in a Waring Blender for 1 minute. Color evaluation was performed with a Hunter Color and Color Difference Meter D25D3A standardized on Hunter tile D33C-1585 (L 25.6, a 27.7, b 12.10, and Tomato Color Measure Index (TCM) 71.50).

Drained weight, pH, and total acidity (TA) were taken exactly as described by Gould *et al* (3).

All tomatoes were prepared for acidified storage by washing, scalding in water at 77° C for 1 minute, and dipping in 100 ppm sodium hypochlorite solution for 1 minute. Juice was made from each cultivar of tomato by washing, chopping, preheating to 76-88° C, extracting using a 0.023 in. screen in a Langsenkamp extractor, high temperature-short time sterilizing (125° C for 32 seconds), cooling to 88° C and acidifying with 22 ml conc. hydrochloric acid/liter of juice. To each storage bag was added 680 g of acidified juice and 680 g of raw tomatoes.

[1]Post Doctorate, Dept. of Horticulture.

Simple correlation analysis was used to determine whether there was a relationship between various parameters examined. Duncan's Multiple Range Test was used to tell whether there were differences among the cultivars tested. This statistical analysis was performed at the OARDC Statistics Laboratory, Wooster.

RESULTS AND DISCUSSION

The influence of cultivars on whole tomato drained weights was found to be significant at the 0.05 level (Table 1) as found by analysis of variance. Cultivars 'US 141' and 'VF 134-1-2' had the highest drained weights while the cultivar 'Chico III' gave the lowest drained weights. There was a poor coefficient of correlation (0.51) between the drained weight of acidified stored tomatoes and conventionally canned product made from the same lot (3). Therefore, it is important to test cultivars for drained weight from acidified bulk storage before inferring that a particular cultivar should be used for storage.

TABLE 1.—Time Averaged Drained Weight and Acidity Measurements of Selected Tomato Cultivars.

Cultivars	Drained Weight (g)	pH	TA
Chico III	435e*	1.28abc	12.2bcd
C 37	520d	1.29abc	12.5bc
VF 134-1-2	619a	1.30ab	11.0bcd
Heinz 414	596ab	1.27abcd	12.7b
Heinz 2567	545bcd	1.31ab	12.6bc
Heinz 2653	593abc	1.30ab	12.6bc
Heinz 2867	593abc	1.25bcd	12.7b
USDA 77B68F1	580abcd	1.34a	11.6d
US 141	625a	1.32ab	12.7b
Ont 744-3	602ab	1.17d	11.9cd
Ont 777	528cd	1.35a	12.2bcd
Kagome 5	547bcd	1.28abc	12.4bc
O 781383	578abcd	1.24bcd	12.0cd
O 7825	588abc	1.25bcd	10.9e
O 7858	579abcd	1.21cd	15.2a
US 28	584abcd	1.36a	12.7b

*Values in a column followed by a common letter are not significantly different at P $\leq$ 0.05 by Duncan's Multiple Range Test.

The pH of the stored product varied slightly from 1.36 to 1.17 among cultivars (Table 1). The error in measuring pH was 0.05. Total acidity altered statistically from cultivar to cultivar and varied from 10.9 to 15.2 (Table 1). These differences reflect a varietal difference in buffering capacity. Although small, these changes merit attention when a processor is considering cultivars for commercial bulk storage.

There were large cultivar variations in the TCM (tomato color measure) of whole tomatoes but not juice (Table 3). These large differences were not seen when subjective color measurements were taken (Table 2). The most desirable tomato color was obtained using the cultivar 'VF 134-1-2'. The least desirable colored cultivar was 'Kagome 5'. Hunter Lab objective color values show this same trend (Table 2). The juice color could not be correlated to the whole tomato color.

There are also large differences in color between products. Tomato juice color was poorer than whole tomato color after acidified storage (Table 3). This can easily be demonstrated by comparing the TCM index scores and noting the high scores are due to carmelization products.

The subjective color measurement was lowest in 'Chico III' and 'C 37'. Other cultivars were not statistically different (Table 3). Subjective color

TABLE 2.—Time Averaged Subjective Evaluation of Selected Tomato Cultivars.

Cultivars	Color	Flavor	Defects	Texture	Overall Appearance	Percent Soft
Chico III	16.67b*	7.67b	10.00e	9.17f	6.67f	64ab
C 37	17.83b	9.00b	10.00e	15.67bcd	9.67e	16cd
VF134-1-2	27.00a	14.13a	14.38ab	19.00abc	14.38a	7bcd
Heinz 414	25.83a	15.17a	13.17abcd	14.50cd	13.83a	32a
Heinz 2567	26.17a	15.33a	12.83abce	15.33bcd	12.67abcd	72bcd
Heinz 2653	26.00a	14.25a	12.63bcd	15.38bcd	12.75abc	27cd
Heinz 2867	26.50a	15.83a	13.67abcd	15.83abcd	13.00abc	39abc
USDA 77B68F1	27.00a	14.50a	14.63a	18.87abc	13.87a	10d
US 141	26.50a	13.88a	14.13abc	19.75ab	14.38a	0cd
Ont 744-3	26.38a	14.00a	14.13abc	16.38abcd	13.13ab	25cd
Ont 777	25.00a	15.83a	10.00e	13.83de	11.17cde	42abc
Kagome 5	26.75a	14.00a	12.50bcd	9.75ef	11.00de	70a
O 781383	27.33a	15.67a	12.50bcd	17.17abcd	13.33ab	18cd
O 7825	27.25a	13.75a	11.63de	15.25cd	11.25cde	33bcd
O 7858	27.25a	14.25a	12.25cd	14.75cd	11.88bcd	41abc
US 28	25.33a	14.33a	13.33abcd	20.83a	13.33ab	27bcd

*Values in a column followed by a common letter are not significantly different at P $\leq$ 0.05 by Duncan's Multiple Range Test.

TABLE 3.—Mean Hunter Color Measurements of Selected Tomato Cultivars.

Cultivars	TCM		Tomato			Juice		
	Tomato	Juice	L	a	b	L	a	b
Chico III	82.17bcde*	107.53	22.13de	21.34e	9.69bcd	17.12e	13.15d	5.67d
C 37	78.53def	88.69	22.51cde	20.90e	9.98abc	17.51de	13.65d	6.68abc
VF134-1-2	77.19f	98.53	23.63a	24.39abc	10.96a	18.74a	17.11a	7.16a
Heinz 414	80.60cdef	105.39	22.67bcde	23.37bcd	10.35abc	17.52de	15.17c	6.33c
Heinz 2567	83.42abc	103.40	22.12de	24.02abcd	9.96abc	17.86bcde	16.26abc	6.74abc
Heinz 2653	81.16cdef	102.12	22.69bcde	24.63ab	10.33abc	17.99bcd	15.57bc	6.67abc
Heinz 2867	80.34cdef	104.30	22.68bcde	23.00cd	10.30abc	17.70cde	15.62bc	6.44bc
USDA 77B68F1	77.50ef	102.01	23.33abc	23.94abcd	10.73ab	18.14abcd	16.56ab	6.73abc
US 141	79.52cdef	102.83	22.95abcd	23.19cd	10.37abc	18.06abcd	16.48ab	6.69abc
Ont 744-3	80.13cdef	97.49	22.79bcde	22.72d	10.12abc	18.76a	16.11abc	7.03ab
Ont 777	85.47ab	103.51	21.89e	25.04a	9.55cd	17.92bcde	16.57ab	6.70abc
Kagome 5	87.00a	102.89	21.90e	24.02abcd	8.73d	17.64de	15.55bc	6.36c
O 781383	77.50ef	98.98	23.49ab	23.86abce	10.86ab	18.44abc	15.79bc	7.01abc
O 7825	81.33bcde	97.68	22.91abcd	23.87abcd	10.34abc	18.29abcd	15.71bc	6.85abc
O 7858	81.57bcde	98.64	22.31de	22.90d	9.95abc	18.57ab	15.88bc	7.02abc
US 28	82.46bcd	105.44	22.28de	23.39bcd	9.97abc	17.65cde	16.05abc	6.49abc

*Values in a column followed by a common letter are not significantly different at $P \leq 0.05$ by Duncan's Multiple Range Test.

scores were not correlated when compared with conventionally canned whole tomatoes taken from the same sample lots (3) (Table 3).

'Chico III' and 'C 37' had the lowest whole tomato flavor scores. This flavor change tasted similar to carmelization flavors found in molasses.

The defect scores revealed a wide cultivar variation. The cultivar 'USDA 77B68F1' had the highest and most desirable scores, whereas the lowest scores were found from 'Chico III', 'C 37', and 'ONT 777'.

There are many specific defects that lowered the quality. The stem scar was a very deleterious defect to the tomato score if it was more than one-fourth inch. Any stylar scar was also read as a defect. The core should be as small as possible. The core was softened to some degree by bulk storage, which may allow the use of tomatoes with a larger core.

The texture scores were highest in 'US 28' and lowest in 'Chico III' (Table 3). The texture measurements and raw texture measurements had a poor correlation coefficient (0.55). Both raw and bulk stored tomato texture masurements and percent soft measurements of acidified storages had a poor correlation (0.49). The cultivars 'Kagome 5' and 'Heinz 414' were the firmest tomatoes while the cultivar 'USDA 77B68F1' had the most softening.

Proper cultivar selection seems to be necessary to obtain proper texture. Texture correlated with raw fruit firmness with a correlation coefficient of 0.55 and was cultivar dependent. The measure percent soft had a correlation coefficient of 0.49 with texture and hardness of raw tomatoes. Since texture was a measure of wholeness and percent soft was a measure of softening, they were not synonymous. Smaller tomatoes (< 5 cm diameter) did not have as high a texture score as larger tomatoes (> 5 cm diameter) in this study. Therefore, a moderate sized fruit may be most desirable.

TABLE 4.—Correlation Coefficients of Various Quality Attributes.

Quality Attribute	TA	TCM Whole Tomatoes	TCM Tomato Juice	Color	Appearance	Flavor	Defects	Texture
TCM Whole Tomatoes	0.126							
TCM Tomato Juice	0.043	0.103						
Subjective Measurements								
Color	—0.116	—0.159	—0.030					
Appearance	—0.007	—0.166	0.091	0.469				
Flavor	0.051	0.109	0.226	0.423	0.506			
Defects	—0.022	—0.123	0.144	0.357	0.727	0.205		
Texture	—0.048	—0.255	0.004	0.097	0.623	0.226	0.445	
Percent Soft	0.056	0.337	0.030	—0.017	—0.475	—0.014	—0.486	—0.51
pH	—0.155	—0.087	0.010	—0.073	0.044	—0.142	0.003	0.072

TABLE 5.—Ranking of Selected Cultivars for Quality After Bulk Storage.

Best	**Fair**
US 141	Heinz 2567
VF 134-1-2	07858
USDA 77B68F1	**Poor**
Heinz 414	07825
Very Good	ONT 777
0781383	Kagome 5
US 18	**Very Poor**
ONT 744-3	C 37
Good	Chico III
Heinz 2867	
Heinz 2653	

The overall appearance score illustrated cultivars with overall characteristics that would make them ideal for use as canned tomatoes from acidified storage (Table 2). Overall cultivar ratings were made based upon these criteria (Table 5).

Many quality attributes were thought to be potentially correlated with each other. However, upon close examination it was found that there were very few good correlations between these attributes (Table 4). The reason for this may have been that there were many types of changes occurring together that affected quality in many ways.

The data show that there are wide variations in the quality of different tomato cultivars after acidified bulk storage. Variations may also be possible by changing cultivar practices, maturity at picking, and chance variation due to environmental conditions. Cultivars should be evaluated on a pilot plant basis before being used for acidified bulk storage.

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Diffusion Rates of Acid Added to Bulk Storage of Tomatoes

RICHARD M. BASEL[1]

ABSTRACT

Whole tomatoes were stored by acidified bulk storage. The pH was lowered by addition of hydrochloric acid to a cover solution and an equal weight of whole tomatoes was added. Acidified storage of whole tomatoes by this method depends upon the infiltration of acid into the tomato fruit. As the pH of the fruit decreased, the pH of the cover solution increased. This diffusion was apparently passive and required several weeks to reach equilibrium. These data indicated that the pH should be determined during this period to allow further acid addition if insufficient acid was added to prevent spoilage.

INTRODUCTION

Long term acidified bulk storage of tomatoes is possible if the equilibrium pH is kept at 1.30 or lower (1). The storage of whole fruit depends upon the infiltration of the acid into the tomato fruit. The rate at which diffusion occurs may be important to the respiration of the tomato and to its possible spoilage during the interim period. The results give insight into the time period required for acid equilibrium.

MATERIALS AND METHODS

Uniform 'Red Rock' tomatoes 5½ cm in diameter were stored in acidified tomato juice. Tomato juice was prepared from tomatoes of the same cultivar and acidified with hydrochloric acid to a pH of 1.80. Equal weights of juice and tomatoes were stored in vacuum sealed polyethylene bags at room temperature. At 1-day intervals, equal weights of juice and tomatoes (approximately 2 kg) were removed from each container. The pH and total acidity of the tomatoes and juice were measured according to AOAC methods (2).

RESULTS

A few weeks were needed to reach an equilibrium pH as shown from the data for pH measurement (Fig. 1). The pH changes rapidly the first few days and then proceeds less rapidly as the differences in pH between cover juice and tomato approach each other. As the pH changed, there was a noticeable darkening of greenish core material. This was due to the loss of magnesium from chlorophyll at low pH. As the pH dropped, there was visible sloughing of the skins.

Total acidity changed roughly equivalently, although curves appeared different, reflecting a differ-

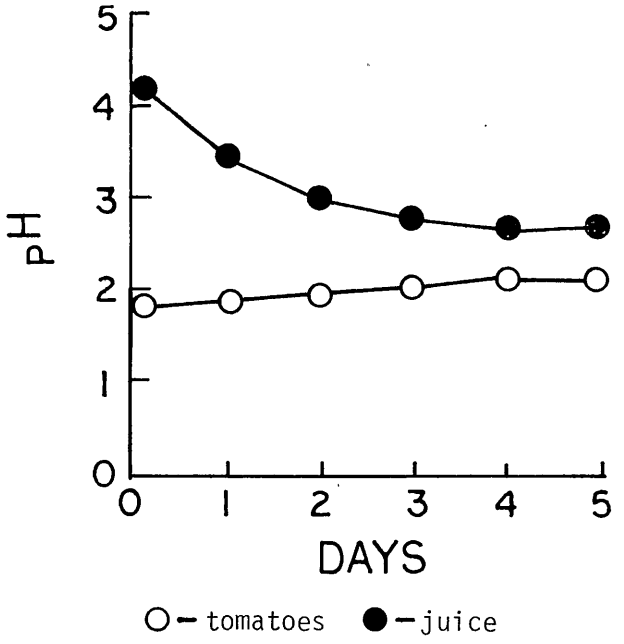

FIG. 1.—Change in pH in tomatoes and juice in storage during diffusion of acid.

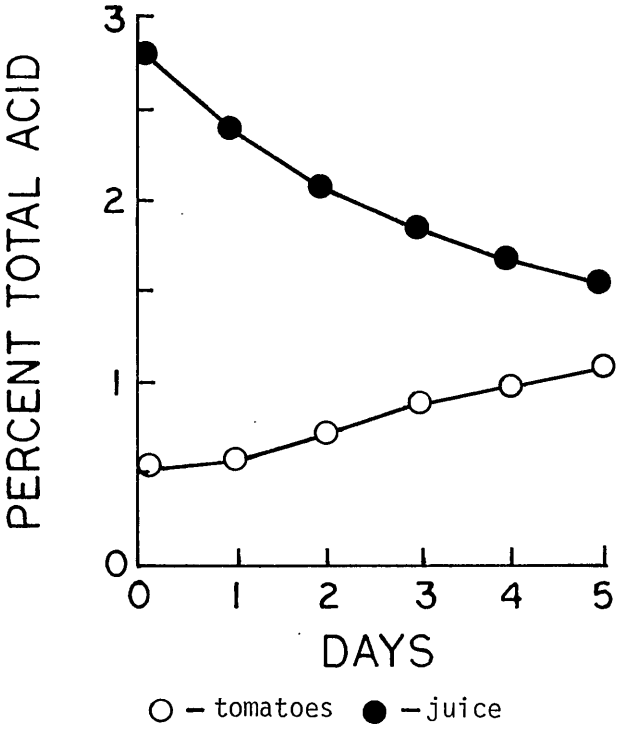

FIG. 2.—Change in percent total acidity in tomatoes and juice in storage during diffusion of acid.

[1]Post Doctorate, Dept. of Horticulture.

ent measurement scale (Figs. 1 and 2). After 1 week, spoilage was not detected. Spoilage due to improper equilibrium pH takes a few days to develop because invading yeasts cannot easily metabolize an extremely acidic environment.

DISCUSSION

The acid diffusion curves were consistent with passive diffusion. By laying pH hydrion paper over a split tomato taken from acidified bulk storage after storage at room temperature for a few days, a gradation of pH through the center was observed. The pH in the center was much higher than the outer perimeter of the tomato. If active transport was responsible for the adsorption of acid, the pH should be less variable. The rate of diffusion may depend on the size of the fruit, the horticultural cultivar, and chemical variations in the fruit. In this experiment the tomatoes were not peeled before storage. It is expected that infiltration times would be shorter if they were peeled prior to acidification.

Since pH varies greatly with time for the first few weeks, pH measurement of cover juice at a few-day interval would be helpful as a quality control measure to insure sufficient acid addition. Additional acid could be added, if needed, to preclude spoilage occurring.

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Auto-Fluorescent Mold Counting

TIMOTHY L. GLAROS and WILBUR A. GOULD[1]

ABSTRACT

The Auto-Fluorescent Mold Count is more objective than the Howard Mold Count because mold hyphae fluoresced bright yellow when using this procedure, providing an additional criterion that can be used by the analyst for distinguishing between tomato fibers and mold hyphae. The Auto-Fluorescent Mold Count is twice as rapid as the Howard Mold Count, allowing the analyst to count 100 fields on 4 slides in the time required to count 50 fields on 2 slides using the Howard Mold Count. The Auto-Fluorescent Mold Count is as sensitive as the Howard Mold Count.

INTRODUCTION

The Howard Mold Count and the Rot Fragment Count are the two official methods for determining the level of mold infestation in tomato products (1). The Howard Mold Count involves examining the food under a conventional light microscope and then counting the number of fields positive for molds.

If the food product is tomato juice, the analyst must first distinguish between tomato fiber and mold hyphae before determining if the mold constitutes a positive field. The process of distinguishing between mold hyphae and tomato fiber is tedious and subjective, leaving much to the analyst.

Several alternatives have been investigated, including a chemical method and fluorescent microscopy. The chemical method is very tedious and time consuming, taking 5½ hours per assay (3). The fluorescent procedure involves staining viable fungi in raw tomato juice with diacetyl fluorescein and then counting the positive fields containing fluorescing mold, using a transmitting fluorescent microscope. The use of diacetyl fluorescein allows only metabolically active mold to fluoresce, which results in fluorescent mold counts that were lower than the Howard Mold Count (2).

An alternative fluorescent method that would allow both viable and non-viable mold to fluoresce would be advantageous. The alternative fluorescent method should be rapid and simple to perform. This study was undertaken to develop a successful alternative to the Howard Mold Count and the diacetyl fluorescein staining procedure that is more objective and simple to perform without the disadvantages of the methods currently available.

MATERIALS AND METHODS

The Auto-Fluorescent Mold Count procedure is a modification of the diacetyl fluorescein staining procedure developed by Fox (2). The Auto Fluorescent Mold Count of raw tomato juice involves placing a few well mixed drops of tomato juice diluted with an equal part of distilled water on a modi-

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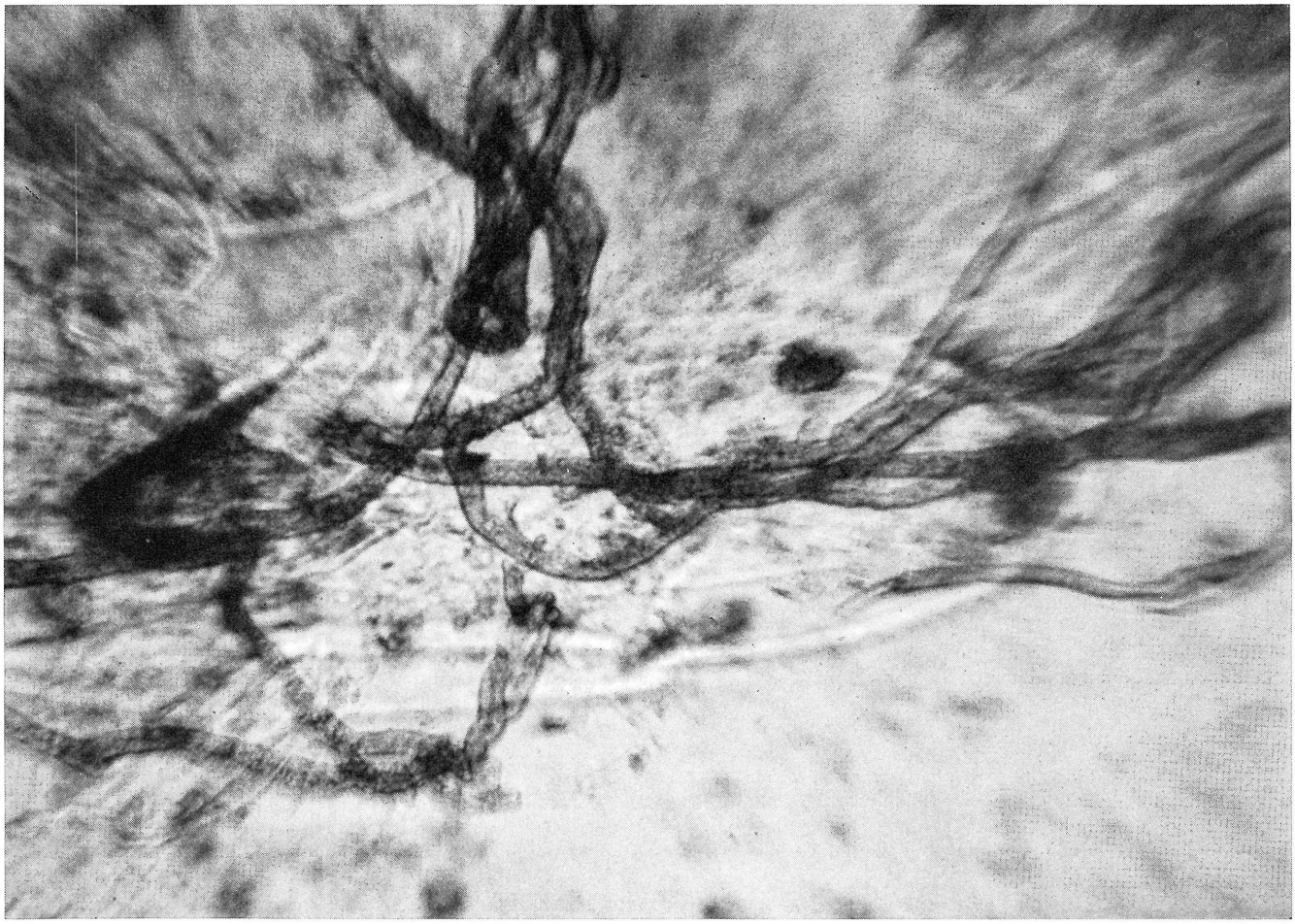

FIG. 1.—Mold hypha in raw tomato juice diluted with one part distilled water, using the conventional light microscope.

fied quartz glass fluorescent antibody slide. The juice must be diluted because the fluorescent microscope utilizes a dark field condenser. Quartz glass fluorescent antibody slides are utilized because they can transmit near UV light.

The slide was modified with shoulders constructed from No. 1 22 x 22 mm cover slips that were approximately 0.1 mm thick. This yielded a sample thickness of approximately 0.1 mm. A No. 1 22 x 40 mm cover slip was placed over the shoulders, allowing the sample to spread uniformly over the mount.

The slide was placed on the stage of the Bausch and Lomb transmitting fluorescent microscope. The transmitting fluorescent microscope was equipped with a 100-watt tungsten-halogen light source. In addition, a paraboloid condenser equipped with a BG-12 exciter filter was used. The BG-12 exciter filter provided a maximum transmittance of 60% at 400 nm. The Schott OG 530 barrier filter was utilized as a means of eliminating the undesirable fluorescent light emitted by the background. The maximum transmittance was 90% at 575 nm. and the maximum absorbance was at 525 nm.

A drop of non-fluorescing immersion oil was placed upon the substage condenser. The substage condenser was brought into contact with the bottom of the fluorescent mold count chamber. The tungsten-halogen light was set at 12 volts. The analyst must count 25 random fields and determine which fields are positive. When using the Auto-Fluorescent Mold Count, mold will fluoresce bright yellow and will be readily detected. The formula for determining the percent positive fields using the Auto-Fluorescent Mold Count is:

$$\text{AFMC} = \frac{\text{No. of positive fields}}{\text{No. of total fields viewed}} \times 2 \times 100$$

RESULTS AND DISCUSSION

Four species of mold were tested for their ability to auto-fluoresce in raw tomato juice diluted with one part distilled water prior to viewing. All four species had the ability to auto-fluoresce when excited

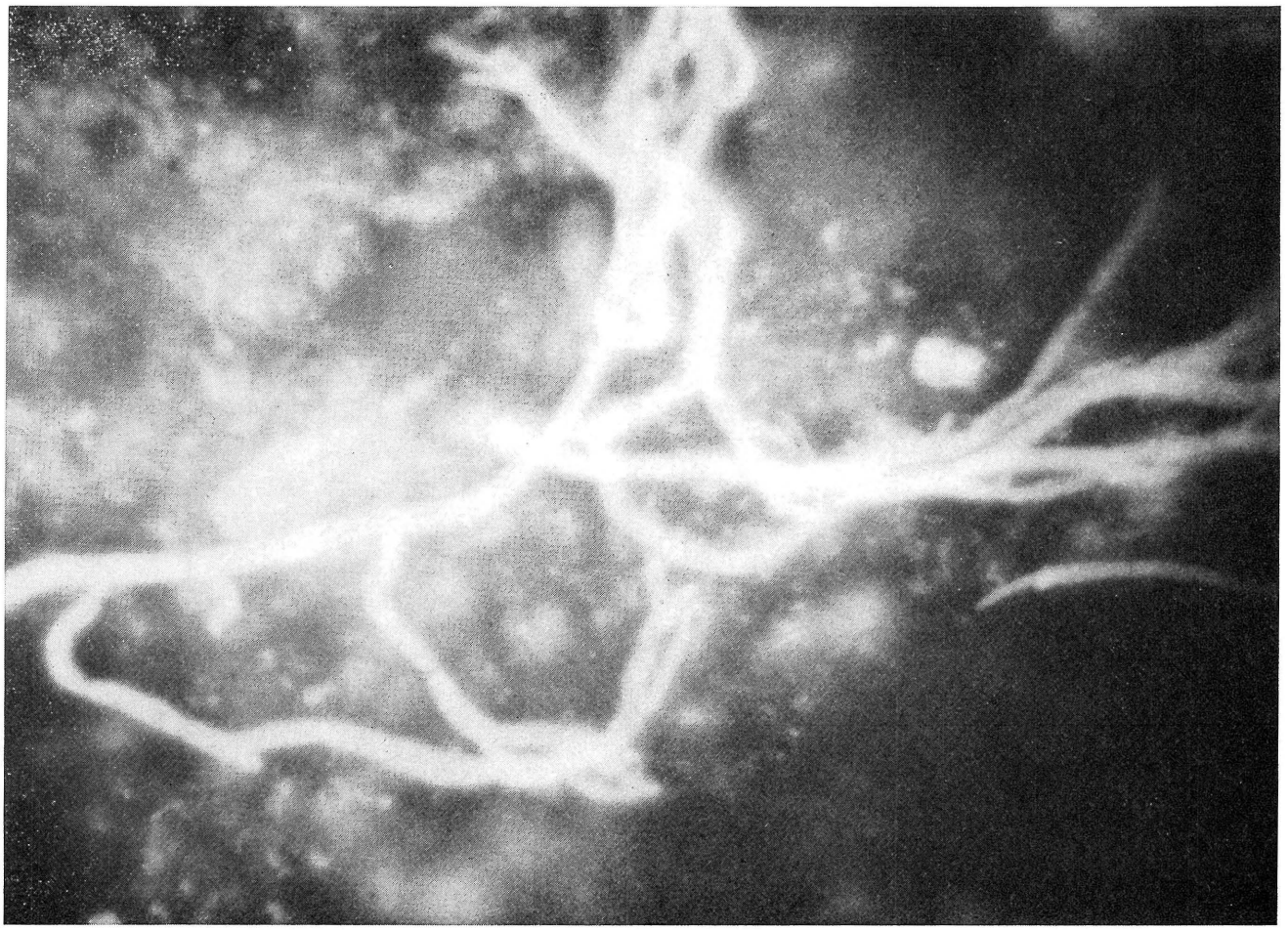

FIG. 2.—Mold hypha in raw tomato juice diluted with one part distilled water, using the transmitting fluorescent microscope.

with near UV light using the transmitting fluorescent microscope.

Figure 1 demonstrates the appearance of mold hypha in diluted tomato juice using the conventional light microscope as in the Howard Mold Count. Figure 2 demonstrates the appearance of the same mold hypha when using the Auto-Fluorescent Mold Count.

The Auto-Fluorescent Mold Count enables all sections of the mold hypha to fluoresce, not just the viable sections as in the diacetyl fluorescein staining procedure. The Auto-Fluorescent Mold Count is more objective because it provides the analyst with one additional criterion for distinguishing between mold hypha and tomato fiber.

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Evaluation of Potato Cultivars for Storage and Chipping

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INTRODUCTION

This study is a continuation of the long-time study to determine the suitability of Ohio potato cultivars for chipping either directly from harvest or after storage. The cultivars included in this year's study were classified as new cultivars recommended for production in the state of Ohio.

MATERIALS AND METHODS

The potatoes were grown on six farms strategically located in the respective potato areas in Ohio. These data, including yield data, are included in a separate report (1).

The potatoes, when considered mature by the grower and the production staff, were machine harvested with a 25 lb sample from each plot removed directly from the picker chain. These 25 lb samples from each replicate were delivered to The Ohio State University Food Processing Pilot Plant. Upon receipt at the pilot plant, an 8 lb sample was removed from each replicate for specific gravity measurement using the hydrometer. The number of tubers per 8 lb was recorded. The 25 lb sample of each replicate was sub-sampled, with up to 3 lb removed for immediate manufacture to chips. The rest of each replicate was blended together with four sub-lots packaged in bags for storage. The sub-lots were placed in 40°F (5°C), 45° F (7.5° C), 50° F (10° C), and 55° F (12.5° C) storage. Following a 6-month storage period, each lot was removed and chipped 1 day, 10 days, and 20 days after reconditioning. Reconditioning was accomplished at room temperature.

The potatoes were manufactured into chips by abrasive peeling for 30 seconds, slicing in a Littrell slicer set for 16 slices per inch, and washed in cold water for 30 seconds. One lb samples were removed from the washed, sliced potatoes and fried in a blend of corn and soy oil, using The Ohio State University continuous chip fryer. The inlet temperature was 375° F (190° C), with a discharge temperature of 350° F (176° C) and a fry time of 110 to 115 seconds depending upon the specific gravity of the raw potato and as indicated by the finished moisture content of the chips, which did not exceed 2.25%.

Following frying, the yield of chips was recorded, the samples were matched to the PC/SFA color chart (1 light and 5 dark scale) using a MacBeth Examolite to uniformly light the samples for color evaluation. Further, a sample was evaluated with the Agtron E5F (red filter) at 0 black disk and the white disk 90 at 90. A sample was also evaluated for blisters (½-inch or greater) and noticeable defects, if any.

RESULTS AND DISCUSSION

The data are presented in summary form for the raw product in Table 1. As indicated in the table, specific gravities are only average for all lots, with 'Denali' the highest. Color was generally good, although not as light as would be expected from fully mature potatoes from the field. Blisters were extensive for the 'Neb. A 129.69-1', 'Crystal', and 'W 718'. 'Michimac', 'Michibonne', 'Katahdin', 'Denali', and 'CA 02-7' were considerably below 'Norchip' for blisters, indicating somewhat better quality. 'Norchip' was the smallest potato in the series with 'Michibonne' the largest.

The data in Tables 2, 3, and 4 show the cultivars by storages after 1, 10, and 20 days reconditioning

[1]Professor, Assistant Professor, and Professor, respectively, Dept. of Horticulture.

[2]The assistance of K. W. Warnke, Technical Assistant, is gratefully acknowledged.

TABLE 1.—Raw Product Quality of Potato Cultivars (Average Value for Six Growers).

Cultivar	Ct./8 lb	Sp. Gr.	PC/SFA Color (1-5)	Agtron Red (M-30) Color	Percent Blisters
Crystal N.D. 8891-3	24.7	1.071	2.8	50.2	32.4
W 718	24.2	1.060	2.2	58.7	32.4
Norchip	31.7	1.070	2.5	56.6	29.1
Michimac MS 711-8	25.3	1.062	2.7	51.8	20.7
Michibonne MS 709	22.8	1.062	3.0	47.7	20.7
Katahdin	26.5	1.062	2.6	50.3	20.0
Denali AK 37-19	24.0	1.078	2.5	46.5	20.6
CA 02-7	24.6	1.070	2.3	55.6	20.4
Neb. A 129.69-1	27.4	1.062	3.2	47.3	56.1

TABLE 2.—Average Values for Six Growers by Cultivars and Handling Treatments, 1980.

			PC/SFA Color (1-5)			
		Reconditioning Period	Storage Temperature °C (°F)			
Cultivar	Raw	Days	5(40)	7.5(45)	10(50)	12.5(55)
Crystal N.D. 8891-3	2.75	1	4.5	2.2	2.3	2.5
		10	3.8	2.6	3.0	4.5
		20	3.3	2.8	2.3	3.5
W 718	2.2	1	4.7	2.4	2.0	2.3
		10	3.5	2.4	2.8	4.0
		20	3.0	2.2	2.2	2.0
Norchip	2.5	1	5.0	2.6	2.5	2.3
		10	3.6	2.2	2.8	
		20	3.5	2.4	2.2	
Michimac MS 711-8	2.7	1	5.0	3.0	3.3	2.8
		10	4.3	3.0	2.8	5.0
		20	3.8	3.0	2.7	2.0
Michibonne MS 709	3.0	1	5.0	3.8	4.0	3.3
		10	4.8	3.4	3.3	3.3
		20	4.3	3.4	3.0	3.0
Katahdin	2.6	1	4.8	3.2	3.2	2.2
		10	3.8	2.6	2.5	3.0
		20	3.2	3.2	2.4	4.0
Denali AK 37-19	2.5	1	4.8	2.4	2.0	2.2
		10	3.8	2.2	2.2	
		20	3.3	2.0	1.7	
CA 02-7	2.3	1	4.0	2.0	2.0	2.2
		10	3.5	1.4	1.6	2.0
		20	3.3	2.0	2.0	2.0
Neb. A 129.69-1	3.2	1	4.3	2.8	3.0	3.3
		10	3.7	2.4	2.8	3.3
		20	3.3	2.8	2.2	2.5

for PC/SFA color, Agtron color, and blisters, respectively. As indicated under PC/SFA color in Table 2, 'Michibonne' did not recondition as well as some of the other cultivars. 'Denali' stands out as an excellent new cultivar. These same data are reflected by the objective color values using the Agtron.

Blisters, as indicated in Table 4, follow somewhat the same trend noted in Table 1, with 'Norchip', 'Neb. A 129.69-1', and 'Crystal' being high while 'Denali' was somewhat lower. All samples, following storage, had excessive blisters in contrast to the raw product samples. No trend could be identified as to storage temperature or reconditioning on onset of blisters. Further work needs to be conducted in this area and efforts directed at elimination of this problem.

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TABLE 3.—Average Values for Six Growers After 6 Months of Storage by Cultivars and Handling Treatments, 1980.

Agtron Red (M-30)						
		Reconditioning Period	Storage Temperature °C (°F)			
Cultivar	Raw	Days	5(40)	7.5(45)	10(50)	12.5(55)
Crystal N.D. 8891-3	50.2	1	28.3	56.8	55.0	54.2
		10	40.0	53.4	50.8	36.8
		20	45.2	53.8	57.0	44.0
W 718	58.7	1	29.8	56.2	56.5	57.3
		10	45.8	58.0	53.2	41.0
		20	48.3	56.6	56.6	57.0
Norchip	56.6	1	27.0	55.6	56.2	56.8
		10	42.0	48.3	53.8	
		20	43.2	54.8	56.8	
Michimac MS 711-8	51.8	1	20.2	50.2	47.0	51.7
		10	34.0	49.0	51.2	32.0
		20	40.3	50.2	53.5	57.0
Michibonne MS 709	47.7	1	19.2	43.2	37.9	46.5
		10	29.7	46.8	44.7	47.7
		20	33.8	43.8	46.0	46.0
Katahdin	50.3	1	26.2	49.2	49.3	56.5
		10	40.5	55.2	56.0	45.5
		20	46.7	49.8	55.0	38.0
Denali AK 37-19	46.5	1	27.0	56.6	59.7	62.3
		10	40.8	58.0	56.3	
		20	45.0	60.2	61.0	
CA 02-7	55.6	1	34.8	60.4	59.7	56.5
		10	44.7	62.6	62.4	57.0
		20	45.6	60.8	60.0	57.0
Neb. A 129.69-1	47.3	1	32.7	53.2	50.0	47.3
		10	43.3	55.6	54.8	44.0
		20	47.0	50.6	56.2	52.0

TABLE 4.—Average Values for Six Growers After 6 Months of Storage by Cultivars and Handling Treatments, 1980.

			Percent Blisters			
			Storage Temperature °C (°F)			
Cultivar	Raw	Reconditioning Period Days	5(40)	7.5(45)	10(50)	12.5(55)
Crystal N.D. 8891-3	32.4	1	48.3	64.0	35.0	46.7
		10	36.7	28.0	27.5	35.0
		20	40.0	68.0	52.5	35.0
W 718	32.4	1	43.3	58.0	46.0	50.0
		10	40.0	48.0	40.0	20.0
		20	38.3	38.0	54.0	70.0
Norchip	29.1	1	30.0	60.0	28.3	40.0
		10	48.0	22.0	38.0	
		20	41.7	42.0	42.0	
Michimac MS 711-8	20.7	1	31.7	48.0	36.7	41.7
		10	43.3	32.0	26.7	20.0
		20	58.3	28.0	48.3	70.0
Michibonne MS 709	20.7	1	38.3	32.0	35.0	41.7
		10	38.3	24.0	21.7	40.0
		20	48.3	30.0	33.3	55.0
Katahdin	20.0	1	28.3	42.0	33.3	38.3
		10	38.3	40.0	35.0	25.0
		20	48.3	34.0	56.0	50.0
Denali AK 37-19	20.6	1	38.3	40.0	36.7	33.3
		10	35.0	38.0	36.7	
		20	38.0	40.0	46.7	
CA 02-7	20.4	1	33.3	34.0	36.7	40.0
		10	33.3	26.0	24.0	40.0
		20	31.7	30.0	40.0	70.0
Neb. A 129.69-1	56.1	1	38.3	66.0	30.0	41.7
		10	65.0	34.0	44.0	56.7
		20	56.7	58.0	42.0	20.0

The Effects of Antioxidants on the Keeping Quality of Potato Chips

W. A. GOULD and SALMAH YUSOF[1]

INTRODUCTION

Lipid oxidation is of great concern to the potato chip manufacturer since it has direct effect on the flavor and keeping quality of the finished product. It is the forerunner to rancid chips and ultimately results in reduced shelf-life of the food product.

The problem of inhibiting the oxidative deterioration of fats is one of the main aims of the snack food industry. Various measures are taken to retard the oxidation process. Presently, the use of chemical antioxidants has been found satisfactory and they are widely used commercially in edible fats and oils and various fatty products.

However, the use of antioxidants in frying oils has been found to be of little or no value in maintaining the keeping quality of potato chips. This problem may be associated with the lack of carry through effect of the antioxidant. Further, it has been reported that some antioxidants are found to break down during the frying operation.

In the potato chip industry, salt is added to the chips after frying to enhance the flavor of the chips. Salt acts both as a preservative and as a flavor enhancer. Chips which are found at the marketplace generally do not have a shelf life longer than 8 weeks after the date of manufacture. To overcome this problem, this study was conducted to determine the effects of using antioxidants in the salt and their effects on the keeping quality of chips.

BACKGROUND—USE OF ANTIOXIDANTS

Antioxidants are substances which can retard the oxidation process. They are widely used commercially in edible fats and oils and snack items to prevent food materials from becoming rancid. Two broad classes of antioxidants are available: natural and synthetic.

Natural antioxidants are present in many animal and vegetable fats but they are often partly removed during industrial processing. This makes it necessary to add synthetic antioxidants in order to increase the stability of fats. A number of natural antioxidants have already been isolated in pure form.

The use of antioxidants is not a simple solution to the oxidation problem. Using them unwisely can cause adverse effects on food products. Several factors must be considered to ensure effective use of the chemical agents. In addition to their capacity to stabilize the substrate, the antioxidants and their conversion products must not be toxic, nor produce color, smell, or taste. They must also have a molecular particle size small enough to permeate the cell wall and it must be soluble to penetrate the aqueous and the lipid phase.

The commonly used synthetic antioxidants include butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate and mono-tertiary—butylhydroquinone (TBHQ). The FDA permits the addition of any of the above singly or in combination of two or more in food products at a maximum concentration of 0.02% based upon the weight of the fat or oil. BHA is one of the best known antioxidants for carry through effect in deep fat fried products. Antioxidants are important to protect the oil from oxidizing from point of manufacture to use. However, most authorities agree the antioxidant effect is lost after the oil is heated during the frying operation.

PROCEDURE

To evaluate the effects of antioxidants applied after chipping, the chips were divided into five groups and given the following treatments:

Group 1—Unsalted

Group 2—Salted

Group 3—Antioxidant blend A containing 30 mg ascorbic acid per 100 g salt

Group 4—Antioxidant blend B containing 60 mg ascorbic acid per 100 g salt

Group 5—Antioxidant blend C containing 0.4% TBHQ, 2% citric acid, 1.5% tricalcium phosphate (TCP), 96.1% salt

Two types of antioxidants were used (ascorbic acid and TBHQ). These antioxidants were mixed with salt and applied to the chips after manufacturing from Katahdin potatoes (1.065 to 1.070 specific gravity) by abrasive peeling for 30 seconds, slicing to 0.063 inch thick, and frying in a blend of cottonseed, corn-soybean oil for 115 seconds at 375° F inlet and 350° F outlet temperature. (The treatments were applied at 1% salt level.) For each treatment, the chips were packed in bags made of two kinds of packaging material. Half of the chips were packed in transparent bags while the other half were packed in

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opaque bags. The chips were then stored under three different storage temperatures, 50° F, 68° F, and 86° F, both in the dark and under continuous light conditions for 8 weeks prior to sensory analysis.

A panel of 10 people was asked to taste the samples to determine the flavor. The samples were scored on a 1 to 10 scale, with 1 off-flavored and 10 perfect. All data were analyzed by using three-way analysis of variance.

RESULTS AND DISCUSSION

The results of the study indicate that the use of low levels of ascorbic acid (30 mg/100 g) improved the flavor of potato chips for the 8-week storage per-

TABLE 1.—Effect of Shelf Life Studies (Storage, Temperature, and Type of Bag) for Potato Chips.

Weeks in Storage	Shelf-Storage (Light vs Dark)	Temperature (50°-68°-86° F)	Bags Transparent vs Opaque
1	—	—	+
2	+	—	+
3	+	—	—
4	+	—	—
5	+	—	—
6	+	—	—
7	—	+	—
8	+	+	—
Rank Effects	1	3	2

Temperature three-way effect: 50 to 68 no effect; 68 to 86 no effect; however, 50 to 86 weekly effects.
— Negative: no significant effect.
+ Positive: significant effect.

TABLE 2.—Average Flavor Scores After 8 Weeks of Storage.

Bag	Shelf Life Conditions	Temperature °F	Unsalted	Salted	Antioxidant 30AA*	60AA†	TBHQ‡
Transparent	Light	50	4.6	6.2	5.6	5.5	6.0
		68	3.8	5.5	5.1	4.9	4.7
		86	3.7	5.4	5.4	4.1	4.5
Average for Samples in Light			4.0	5.7	5.4	4.8	5.1
	Dark	50	4.3	6.7	7.2	7.3	7.0
		68	4.2	5.7	5.6	6.0	6.4
		86	3.8	5.8	6.8	6.0	5.8
Average for Samples in Dark			4.1	6.1	6.5	6.4	6.4
Average for Samples in Transparent Bag			4.1	5.9	5.9	5.6	5.8
Opaque	Light	50	3.4	4.1	6.2	5.6	5.2
		68	4.2	5.5	6.8	5.8	6.0
		86	4.4	5.9	6.1	5.6	6.1
Average for Samples in Light			4.0	5.2	6.4	5.7	5.8
	Dark	50	3.9	4.4	6.7	6.1	6.0
		68	4.5	5.5	6.6	5.8	6.9
		86	4.3	5.5	6.1	6.0	6.4
Average for Samples in Dark			4.2	5.1	6.5	6.0	6.4
Average for Samples in Opaque Bag			4.1	5.2	6.5	5.9	6.1
Average for all Samples Stored in Light			4.0	5.5	5.9	5.8	5.5
Average for all Samples Stored in Dark			4.2	5.6	6.5	6.2	6.4
Average for all Samples Stored at 50°			4.1	5.4	6.4	6.1	6.1
Average for all Samples Stored at 68°			4.2	5.6	6.0	5.6	6.0
Average for all Samples Stored at 86°			4.1	5.7	6.1	5.4	5.7
Average for all Samples			4.1	5.5	6.2	5.7	5.9

*30 mg ascorbic acid.
†60 mg ascorbic acid.
‡0.4 % mono-tertiary-butylhydroquinone.

iod when compared to the use of salt alone or the other antioxidants. The use of high levels of ascorbic acid (60 mg/100 g) caused the chips to develop a bitter flavor.

The antioxidants seemed to be more effective when samples were stored in the dark under low temperature. This was evident from the higher flavor scores obtained for the samples up to the 8th week. Chips packed in opaque bags were preferred when compared to those packed in transparent bags. This was apparent under most storage conditions, especially at 50° F storage temperature.

The unsalted chips were generally ranked low; in fact, these chips began to develop off-flavors after 1 week of storage (Tables 1 and 2). The salted chips were ranked higher than the unsalted ones.

Varietal Effects on Cabbage Lipid Composition

ANDREW C. PENG[1]

INTRODUCTION

Cabbage, *Brassica oleracea* var. *Capitata,* one of the cruciferous vegetables, is low in calories, fairly high in nutritional value, and adaptable to domestic or processing uses. The main component responsible for such low energy value is primarily the lipid content. This laboratory has studied cabbage lipids (4); the effect of fermentation, processing, and storage on lipid composition of sauerkraut (5); and cabbage lipid changes during storage (6).

The purpose of this investigation was to determine the varieal influence on total lipid content and fatty acid composition of four cabbage cultivars.

MATERIALS AND METHODS

Four cultivars of cabbage (cultivars King Cole and Golden Acre Yellows Resistant grown on The Ohio State University horticultural farm, Columbus, and HiDri cabbage cultivars 364 x 326 and 364 x 328) were obtained from the OARDC, Wooster. All cultivars utilized in this study were grown under accepted commercial practices for this region. Heads were harvested by hand and transported to the Dept. of Horticulture, Howlett Hall, on the OSU campus.

Preparation of Sample

The outer leaves were removed and the head was cleaned. The clean head was cut into quarters, and shredded 1/32-inch with a hand kraut cutter. The shredded cabbage was thoroughly mixed in order to evenly distribute lipids.

A sample weighing 200 g was placed in a plastic bag and frozen for future analysis. Moisture content was determined by weight differences after drying in a recirculating oven at 100 ± 5° C for 20 hr.

Lipid Extraction

Duplicate frozen samples were blended with 200 ml distilled water in a Waring Blendor for 3 min. The slurry was mixed thoroughly with 20 g silicic acid and 10 g Celite. This mixture was filtered thoroughly with Whatman No. 1 paper in a Buchner funnel under reduced pressure until continuous water drop was no longer observed.

The sample pad was extracted in a Waring Blendor with 200 ml Folch reagent (1) consisting of chloroform-methanol (2:1, v/v) for 3 min at room temperature and filtered in a same manner as mentioned above. The residue was re-extracted with a 200 ml aliquot of solvent, filtered, washed twice with 25 ml solvent/washing and once with 25 ml chloroform.

The combined extract was transferred quantitatively to a separatory funnel and allowed to stand for 5 to 10 min. The lower lipid phase was collected; the upper aqueous phase was washed with 30 ml chloroform and combined with the two lower phases. The extract was left in a refrigerator overnight in the separatory funnel for complete separation of the two phases. The lower lipid phase was collected and the solvent was removed by rotary evaporation at reduced pressure. The lipid samples were stored in a vacuum desiccator until a constant sample weight was obtained for analysis.

Fatty Acid Analysis

Lipid sample was hydrolized and the resulting fatty acids were methylated with boron-trifluoride methanol (2). Quantitative and qualitative determinations were performed by gas-lipid chromatography with a Packard model 409 Becker gas chromatograph equipped with a flame ionization detector, Bristol's Dynamaster recorder, and disc chart integrator as previously reported (4). Identification of fatty acids on the chromatogram was made by comparing the retention time of reference compounds and by plotting retention time vs. carbon number on semilog paper for supplementing those other than reference compounds run on the same column under the same condi-

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tions. The fatty acids were expressed as area percentage of the total area from all methyl esters.

RESULTS AND DISCUSSION

The moisture content of four cabbage cultivars (Table 1) ranged from 90.57% to 93.72%. Only Golden Acre Yellows Resistant cultivar was close to the value cited in the USDA Handbook, 92.40%. The two high solids cabbage inbreds had the lowest moisture which proved that their solids were higher than the standard cultivars.

A range of 0.10% to 0.16% total crude lipids was found from different cultivars (Table 1). As compared with Pederson and Albury's findings (3), 0.15% to 0.20%, only Golden Acre Yellows Resistant cultivar was in that range, and the other cultivars were all below those, especially cultivar King Cole lipids which were 50% to 100% lower than the reported figure.

Data shown in Tables 1 and 2 demonstrate the varietal influence on cabbage lipids and fatty acids. Although the pattern and distribution of fatty acid composition varied from cultivar to cultivar, they reveal a typical plant lipid pattern of predominantly palmitic (16.0), oleic (18:1), linoleic (18:2), and linolenic (18:3) acids of which the two HiDri cultivars are representative. King Cole contains the highest palmitic and heptadecenoic (17:1) acids and its major acid distribution is 16:0>17:1>18:0>18:1>18:3>18:2>, while Golden Acre Yellows Resistant has major acid distribution of 18:3>18:2>18:1>16:0>18:0>16:1. The high level of lignoceric (24:0) and nervonic (24:1) acids may be an artifact developed during GLC analysis. HiDri 364 x 326 has a decreasing order of 18:3>18:1>18:2>

TABLE 1.—Moisture Content and Total Lipids of Different Cabbage Cultivars (Percent Dry Weight Basis).

Cultivar	Moisture	Total Lipids
King Cole	93.72	0.10
Golden Acre Yellows Resistant	92.57	0.16
HiDri 364 x 326	90.57	0.14
HiDri 364 x 328	91.93	0.12

TABLE 2.—Fatty Acid Composition of Different Cabbage Cultivars (Percent Dry Weight Basis).*

Fatty Acid†	Cabbage Cultivar			
	King Cole	Golden Acre Yellows Resistant	HiDri 364 x 326	HiDri 364 x 328
9:0	2.3	—	0.5	Tr
10:0	1.5	—	2.3	Tr
11:0	1.3	—	1.1	Tr
12:0	0.9	1.6	0.9	Tr
13:0	0.5	0.6	1.3	—
?	Tr	2.0	1.0	—
14:0	1.8	2.9	2.2	Tr
14:1	Tr	1.2	0.7	Tr
15:0	2.5	2.3	2.4	1.1
15:1	1.5	1.4	1.8	Tr
16:0	20.8	7.5	14.1	14.0
16:1	4.5	2.6	5.4	1.4
17:0	0.9	0.6	1.2	1.1
17:1	12.4	1.0	1.6	0.5
18:0	6.2	5.4	3.2	2.6
18:1	3.4	10.8	14.6	12.6
19:0	—	—	2.2	0.6
18:2	0.9	14.0	14.2	21.1
20.0	0.8	1.1	2.0	0.8
18:3	1.1	16.9	17.1	26.2
21:0	1.8	0.8	1.7	1.0
21:1	2.5	0.9	—	1.3
22:0	4.2	0.5	3.0	1.7
?	—	2.1	—	—
22:1	7.1	—	Tr	2.0
23:1	5.2	Tr	—	—
24:0	5.9	21.1	—	4.5
24:1	8.9	1.9	—	—

*Only 0.5 % or more reported.
†Carbon number: number of double bond.

16:0>16:1>18:0 fatty acids whereas 364 x 328 shows 18:3>18:2>16:0>18:1>18:0>16:1. This discrepancy in lipid content (Table 1) and fatty acid composition proved the varietal influence on plant components.

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Effect of Maturity and Skin Contact on the Inorganic Constituents in Vidal Table Wines

J. F. GALLANDER[1, 2]

INTRODUCTION

During the fermentation process, many inorganic elements are essential for the synthesis of alcohol. These minerals include potassium, manganese, magnesium, iron, and copper. Another important element is phosphorus, because it is essential for yeast growth. For making wine, the level of inorganic constituents in grape juice is adequate to support a fast and sound fermentation. This is unlike other wines which require the addition of certain elements to aid fermentation.

Although several elements are beneficial to the fermentation process, some have an undesirable effect upon the stability of the finished wines. In general, these problems arise from excesses rather than deficiencies of certain elements. Excessive amounts may produce wine defects which are associated with color, appearance, or taste of the wines. For example, copper in the wine may form complexes with other compounds to produce clouds which detract from the appearance of the wine. High levels of copper also may increase the browning rate in white wines. Sources of high mineral levels in wines may arise from the inherent content in juices, winery equipment, and vineyard materials.

The literature contains considerable data on inorganic constituents in grapes and wines. An excellent review of inorganic elements in wines has been provided by Amerine (2). However, most of the data pertain to wines from *Vitis vinifera* grapes. Little information is available on wines from eastern United States, particularly French hybrid wines. This study was conducted to determine the inorganic constituents of wines made from Vidal blanc, a newly established and popular white French hybrid grape in Ohio. Three time periods of skin contact also were included in this experiment. A short time on the skins prior to pressing is sometimes used commercially to increase the varietal character of the wines.

MATERIALS AND METHODS

Fruit from Vidal blanc were harvested at three maturity levels (° Brix) in 1979 from a commercial vineyard in northern Ohio. After the grapes were harvested at early, mid, and late stages of maturity, they were transported to the OARDC in Wooster. Following storage at 2° C for approximately 12 hours, the grapes were destemmed, crushed, and divided into three lots and duplicated. The musts were treated with 100 ppm of sulfur dioxide in the form of potassium metabisulfite.

One lot was immediately pressed while the other two lots were pressed after 5 and 10 hours, respectively. From the soluble solids readings (° Brix), the juices from the treatments early and mid stages of maturity were ameliorated with sucrose to bring the soluble solids content to 21%. No amelioration was performed on the juice from the late harvested grapes

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[2]The assistance of Judith F. Stetson, Agricultural Technician, Dept. of Horticulture, is gratefully acknowledged.

(21.8° Brix). After amelioration, the juices were transferred to glass carboys (15 liters each).

Twelve hours after the sulfur dioxide treatment, each lot was inoculated with 2% v/v active yeast culture of *Saccharomyces cerevisiae,* Montrachet No. 522. All carboys were equipped with water seals and were placed in 18° C storage for fermentation. When the wines reached dryness, they were racked and treated with 20 ppm sulfur dioxide. After additional rackings (during a 6-month period), the wines were clarified with bentonite and filtered. The wines were then cold stabilized, bottled, and analyzed for composition.

After pressing, all juices were tested for soluble solids (° Brix), pH, and total acidity. These determinations were made as described by Amerine and Ough (4). The analyses of the inorganic elements were performed by a direct reading emission spectrograph.

RESULTS AND DISCUSSION

The soluble solids increased and total acidities decreased in the juices during maturation (Table 1). With this decrease in total acidity, there was also a corresponding increase in pH. Certain organic acids in grapes, particularly tartaric and malic acids, decrease during ripening, with malic acid decreasing more rapidly than tartaric (5). Highest pH values were also obtained in wines made from late-harvested grapes (Table 1).

The pH of the juices and wines also increased when pressing was delayed for 5 and 10 hours (Table 1). This rise in pH was probably due to the extraction of basic compounds from the skins and pulp during the holding periods. At each maturity level, there was a large decrease in potassium, calcium, and magnesium contents with skin contact (Table 2). For example, these data showed that the potassium content in the wines increased from 400 to 481 mg/liter

TABLE 1.—Chemical Analysis of Vidal Blanc Juice and Wine at Three Maturity Levels and Three Time Periods of Skin Contact, 1979 Season.

Stage of Maturity	Harvest Date	Skin Contact (hr)	Juice			Wine	
			° Brix	pH	Total Acidity* (g/100 ml)	pH	Total Acidity* (g/100 ml)
Early	Oct. 2	0	17.9	3.02	1.39	2.83	0.87
		5	17.6	3.15	1.42	2.91	0.88
		10	17.6	3.16	1.35	2.95	0.89
Mid	Oct. 15	0	18.9	3.01	1.29	2.87	0.78
		5	18.6	3.25	1.19	2.92	0.75
		10	18.6	3.21	1.21	2.98	0.74
Late	Oct. 31	0	21.7	3.18	1.13	2.93	0.77
		5	21.8	3.28	1.12	3.03	0.76
		10	21.7	3.29	1.14	3.04	0.75

*Total acidity as g tartaric acid per 100 ml.

TABLE 2.—Inorganic Constituents of Vidal Blanc Wines Made from Fruit at Three Stages of Maturity and Three Time Periods of Skin Contact, 1979 Season.

Elements	Fruit Maturity Level								
	Early			Mid			Late		
	Skin Contact (hr)			Skin Contact (hr)			Skin Contact (hr)		
	0	5	10	0	5	10	0	5	10
	mg/liter								
Potassium	400	481	532	411	453	494	411	484	498
Calcium	70	100	101	55	86	89	60	86	89
Magnesium	79	84	86	77	85	87	88	99	101
Phosphorus	42	65	66	49	55	58	51	68	68
Iron	16	14	13	10	11	10	13	11	11
Sodium	14	13	12	12	12	12	14	13	13
Boron	2.1	2.3	2.5	2.3	2.3	2.3	2.7	2.6	2.5
Manganese	1.2	1.2	1.2	1.1	1.3	1.4	1.5	1.8	2.0
Copper	0.3	0.4	0.6	0.4	0.5	0.5	0.6	0.6	0.6
Zinc	0.4	0.5	0.5	0.3	0.6	0.5	0.5	0.7	0.6

when the crushed grapes at early maturity were held for 5 hours. A further increase in potassium content also was obtained at 10 hours' skin contact. This was in contrast to the calcium and magnesium contents which tended to be the same for 5 and 10 hours.

The literature indicates that these three cations are lower in wines than in the pressed juices (3, 6). During the fermentation process and stabilization practices in making wine, certain amounts are removed through precipitation with organic acids. The only other element which increased in the wines with skin contact was phosphorus. The loss of phosphorus from juice to wine is mainly due to its uptake by yeast cells during fermentation. The results of the remaining six elements indicated that their content in the wines was not affected by skin contact.

During grape maturation, the levels of some inorganic constituents change while others remain constant. Amerine (1) reported that the calcium content remained nearly constant while potassium and sodium contents increased with ripeness. These trends within the fruit may not be reflected in their wines because varying amounts are lost during vinification. From this study, the results indicated that the levels of potassium, phosphorus, sodium, boron, copper, and zinc in the wines tended to remain the same at all stages of fruit maturity (Table 2).

Most of the elemental concentrations from these wines are in agreement with those of Amerine *et al.* (3). However, the copper levels were considered high, approximately 0.5 mg/liter. This small amount of copper is important because it may cause cloudiness or flavor change in wines. Amerine (2) reported that new wines usually contain 0.1 to 0.3 mg/liter of copper. Iron was also found in relatively high amounts, 10 to 16 mg/liter. Wines containing more than about 7 to 10 mg/liter are known to be highly susceptible to cloudiness and oxidation.

The reasons for the high levels of copper and iron in the wines are not evident from the available data. All wines were vinified with minimum contact with metals and were stored in glass containers. However, it is possible that the high copper and iron concentrations were related to the variety, season, and vineyard location used in this study.

The amounts of magnesium and manganese in the wines were found to increase with grape maturation (Table 2). For late-harvested grapes, the magnesium content ranged between 88 to 101 mg/liter for the three skin contact periods. The overall average for manganese was 1.4 mg/liter. These levels were in agreement with those reported by Amerine *et al.* (3). The calcium content in the wines decreased during the early period of the season. Then the level of calcium remained nearly constant from mid to late in the season.

In summary, the levels of inorganic constituents in the Vidal blanc wines were typical and were within the range of most wines. The only two elements which tended to be high were copper and iron. In a few cases, their concentrations were slightly above the recommended amounts which should be present in finished wines.

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Composition and Quality of White Table Wines Fermented with Strains of *Schizosaccharomyces pombe*

J. F. GALLANDER[1]

INTRODUCTION

When wines are made from grapes grown in a relatively cool climate, such as the eastern United States, an excessive amount of tartness usually occurs in the wines. This tartness is mainly due to the high levels of tartaric and malic acids. These acids and their salts usually account for 90% or more of the total acidity in grapes (2).

Although there are several winemaking practices to reduce wine acidity, this study was only concerned with one method of wine deacidification, malic acid fermentation with *Schizosaccharomyces pombe*. This yeast has the ability to metabolize malic acid to ethanol and carbon dioxide. Studies concerning the inoculation of *Schiz.* cultures in grape musts indicated that the amount of acidity reduction was quite variable (3, 5, 6). Yang (7) reported an appreciable reduction in acidity, as much as 34%, was obtained by inoculating with *Schiz. pombe*.

Although the wine acidity is reduced, several studies have found that off-flavors and aromas are produced by the yeast during fermentation. For this reason, a study was initiated to determine effects of various *Schiz.* yeast strains on malic acid degradation and wine quality.

MATERIALS AND METHODS

In 1977, Vidal blanc and Delaware grapes were obtained from a commercial vineyard in northern Ohio. Again in 1978, Delaware and Seyval were obtained from the same location. The grapes were immediately destemmed, crushed, and pressed after harvesting. The juices were analyzed for soluble solids (° Brix), pH, and total acidity, and were treated with 100 ppm of sulfur dioxide in the form of potassium metabisulfite. From the soluble solids readings, the juices were ameliorated with sucrose to bring the soluble solids content of each variety to 21%.

The juice of each variety was divided into four lots (15 liters each) and transferred to glass carboys. Twelve hours after the sulfur dioxide treatments, one lot of each varietal juice was inoculated with 2% v/v active yeast culture of *Saccharomyces cerevisiae* (control), and the other three lots with strains of *Schizosaccharomyces pombe*. All carboys were equipped with water seals and were placed in 18° C storage for fermentation. When the wines reached dryness, they were racked and treated with sulfur dioxide. After additional rackings (during a 6-month period), the wines were clarified with bentonite and filtered. The wines were then cold stabilized, bottled, and analyzed for composition and quality.

Yeast Cultures: The *Saccharomyces cerevisiae* was the "Montrachet No. 522" strain and the *Schizosaccharomyces pombe* strains were 105, 106, and O-77. The *Schiz. pombe* strains were obtained from Bayerische Landesanstalt fur Weinbau und Gartenbau, Wurzburg, Germany, and the Institute for Wine and Food Technology, Kofu City, Japan. The yeasts were grown in pre-sterilized grape juice for 48 hours prior to juice inoculation.

Chemical Analysis: Total acidity, pH, soluble solids, alcohol, volatile acidity, and tartaric acid were determined as described by Amerine and Ough (1). The L-malic acid content of the wines was determined enzymatically with malic dehydrogenase (4).

RESULTS AND DISCUSSION

The analytical data of the must composition for the varieties are shown in Table 1. The soluble solids were highest (19.8%) for Vidal blanc in 1977. The pH values varied widely, with Seyval in 1978 having the lowest (3.07) and Vidal blanc in 1977 the highest value (3.26). Most of the total acidities were above the acceptable level for table wines. In 1977, Vidal blanc was highest at 1.29%.

The results of the wine composition indicated that the *Schiz.*-fermented wines were lower in total acidity than the *Sac.*-fermented wines (Table 1). The average reduction was approximately 28%, with a range of 8% to 53%. The greatest amount of deacidification occurred in the 1977 Vidal blanc wines, with strain 106 ranging from 0.96% to only 0.45% total acidity. These results were similar to those of Benda and Schmitt (3), but were greater in deacidification than those reported by Yang (7) and Peynaud and Sudraud (5).

The lowering of the total acidity was due to the malic acid fermentation by *Schiz. pombe*. Results showed that the decomposition of L-malic acid was influenced by the strain of *Schiz. pombe*. Seyval wines in 1978 fermented with strains 105 and 106 contained a trace of malic acid while wines of strain O-77 contained 0.25%.

The level of malic acid degradation was also affected by the grape variety. For example, strain 106

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TABLE 2.—Aroma Evaluation of Wines Fermented with Strains of Schizosaccharomyces pombe **and** Saccharomyces cerevisiae.

Yeast	Triangle Test: No. of Tasters	Triangle Test: No. Correct	Triangle Test: Significance Level	Aroma*
		Delaware, 1977		
Schiz. 105	20	14	0.1 %	4.6
Schiz. 106	20	11	0.5 %	4.2
Schiz. O-77	20	15	0.1 %	4.1
Sacch.				4.7
		Vidal blanc, 1977		
Schiz. 105	20	13	1.0 %	4.5
Schiz. 106	20	19	0.1 %	2.9
Schiz. O-77	20	14	0.1 %	3.7
Sacch.				5.0
		Delaware, 1978		
Schiz. 105	20	16	0.1 %	4.3
Schiz. 106	20	19	0.1 %	4.3
Schiz. O-77	20	17	0.1 %	4.7
Sacch.				4.5
		Seyval, 1978		
Schiz. 105	20	18	0.1 %	3.6
Schiz. 106	20	15	0.1 %	3.8
Schiz. O-77	20	16	0.1 %	4.6
Sacch.				4.7

*Rated on 7-point hedonic scale, with 7 the most acceptable.

TABLE 1.—Chemical Analysis of Wines Fermented with Strains of Schizosaccharomyces pombe **and** Saccharomyces cerevisiae.

Yeast	Soluble Solids (°B)	pH	Total Acidity*	Volatile Acidity†	Total Tartrates g/100 ml	Total Malates g/100 ml
			Delaware, 1977			
Must	19.0	3.25	1.26			
Sacch.		3.22	0.98	0.052	0.17	0.42
Schiz. 105		3.42	0.59	0.048	0.17	0.16
Schiz. 106		3.37	0.69	0.046	0.19	0.24
Schiz. O-77		3.41	0.63	0.054	0.18	0.16
			Vidal blanc, 1977			
Must	19.8	3.26	1.29			
Sacch.		3.10	0.96	0.023	0.21	0.51
Schiz. 105		3.21	0.80	0.027	0.21	0.38
Schiz. 106		3.48	0.45	0.034	0.22	0.02
Schiz. O-77		3.41	0.49	0.023	0.21	0.02
			Delaware, 1978			
Must	18.6	3.11	1.06			
Sacch.		3.22	0.86	0.040	0.43	0.37
Schiz. 105		3.25	0.72	0.045	0.44	0.12
Schiz. 106		3.22	0.71	0.042	0.39	0.12
Schiz. O-77		3.19	0.79	0.054	0.45	0.21
			Seyval, 1978			
Must	18.2	3.07	0.79			
Sacch.		2.96	0.60	0.040	0.36	0.23
Schiz. 105		3.06	0.43	0.054	0.32	Trace
Schiz. 106		3.05	0.42	0.048	0.30	Trace
Schiz. O-77		2.98	0.55	0.051	0.37	0.21

*Total acidity as g tartaric acid per 100 ml.
†Volatile acidity as g acetic acid per 100 ml.

in 1977 fermented most of the malic acid in Vidal blanc while Delaware wines contained 0.25%. Factors such as pH, sulfur dioxide, and naturally occurring yeasts in the wines may account for the varietal differences. *Schiz. pombe* yeasts are slow fermenters and are easily overgrown by some natural yeasts.

Results also indicated that the *Schiz.* fermentation brought about an increase in pH through the loss of malic acid. Since the pH levels were not increased to 3.6, the tartrate concentrations within each varietal wine were nearly identical. In addition, the volatile acidities of the *Schiz.*-fermented wines were about the same as the *Sac.*-fermented wines. All values were below the U. S. legal limit.

Studies have shown that *Schiz.*-fermented wines often possess off-aromas. For this reason, sensory tests were designed to determine if any aroma differences existed between the *Sac.* and strains of *Schiz.*-fermented wines. Results of the triangle tests in 1977 demonstrated that Vidal blanc and Delaware wines produced with strains of *Schiz. pombe* were significantly different from the *Sac.*-fermented wines (Table 2). Although the panelists were able to differentiate the wines fermented by 105, the results of the aroma rankings indicated that 105 wines were not objectionable. Similar results were obtained for the 1978 wines, but the only wines which were comparable to the *Sac.*-fermented wines were from the O-77 strain. This was true for both varietal wines, Delaware and Seyval.

Comparison of these results indicates that the off-aromas of the *Schiz.* wines are associated with the degradation of malic acid. The panelists ranked the *Schiz.* wines lowest when most of the malic acid was metabolized. It appears that the completeness of malic acid fermentation is influenced by the naturally occurring yeasts. This may also explain the variability in this study. Depending upon such factors as variety and season, grape musts have been found to be quite variable in the number and types of natural yeasts.

In summary, when most of the malic acid was reduced, the *Schiz.* wines were found to be atypical in aroma. However, results indicated that partial malic acid fermentation by strains 105 and O-77 produced wines with similar quality (aroma) to *Sac. cerevisiae.*

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Effect of Variety and Harvest Date on the Quality of Frozen Strawberries

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INTRODUCTION

One of the most important factors in producing high quality frozen strawberries is the selection of a suitable variety. Such a variety should possess bright and uniform red color, light color seeds, no center cavity, delicate and distinctive flavor, and firm texture. In addition, the frozen product should be rich in Vitamin C. Strawberries are a good source of Vitamin C, with an average serving usually providing the adult minimum daily requirement (30 mg) of this vitamin.

Since new varieties are constantly being developed and the need for improved varieties is increasing, a continuing study is underway at the OARDC to ascertain the suitability of promising new varieties and selections for freezing (1, 2). This study also included an investigation to determine the effect of harvest date of several varieties and selections on the quality of frozen strawberries. The information from these studies should serve as a guide to breeders, commercial processors, and homemakers as to those strawberries which will produce a high quality frozen product.

MATERIALS AND METHODS

Fourteen strawberry varieties and selections were evaluated during the 1980 season. These strawberries were grown in the Research Center's horticultural plots in Wooster. A representative fruit sample (2.7 kg) of each strawberry was collected on two different harvest dates. The first harvest was approximately 7 days in advance of the second. The berries were fully colored at harvest.

After the strawberries were washed, drained, and sorted, the caps were removed and each berry was sliced in half. At this time, a sample was taken for chemical analysis. Then, 1.8 kg of sliced berries were mixed with 0.45 kg of sugar. The sugared berries were packed and sealed in moisture-vapor-proof containers and placed in —15° F freezer storage.

After 6 months' storage, the frozen strawberries were thawed, coded, and subjected to a 10-member taste panel for sensory evaluation. Each panelist was asked to score the strawberries on a preference scale of 1 through 5 (5 being the most acceptable) for color, flavor, texture, and wholeness. The evaluation was repeated twice for each variety or selection and harvest date.

In addition to the taste panel evaluation, chemical analyses were performed on the fresh fruit and thawed berries. Two representative samples of each were obtained and analyzed as follows:

pH: The pH was determined by the glass electrode method (Orion Research Model 701A, Digital pH Meter), using juice of each variety and selection.

Total Acidity: A 10 ml juice sample was titrated with a 0.1 N sodium hydroxide solution. The percent total acidity was calculated as citric acid.

Total Soluble Solids: The soluble solids content was determined by using an Abbe refractometer.

Vitamin C (ascorbic acid): The ascorbic acid was extracted from each sample by using a Waring blender and oxalic acid. Then the extracted ascorbic acid with an indophenol dye was measured with a photoelectric colorimeter.

RESULTS AND DISCUSSION

Results of the chemical composition of the fresh strawberries are presented in Table 1. For the two harvest dates, the selection Md. US 4380 was found to be lowest in pH and highest in total acidity. This selection and the variety Earliglow were highest in soluble solids, a good indication of the sugar content. A trend was observed to indicate that fruit from the second harvest was highest in soluble solids. In addition, the vitamin C content for most of the varieties and selections decreased from the first to the second harvest.

The chemical composition of the various varieties and selections was affected by the processing treatment (Table 2). Certainly the addition of sugar during the preparation of the product for freezing was the major influence. When comparing the composition of the fresh to the frozen product, the pH increased and the total acidity and vitamin C decreased for all strawberries. As expected, the soluble solids increased, with a range in the frozen product between 21.5% to 40.2%.

In addition, the chemical composition of the frozen strawberries was affected by the harvest dates (Table 2). The results indicated that the vitamin C content for most of the strawberries was lowest at the second harvest. The average vitamin C content for

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the first and second harvests was 36 and 31 mg per 100 g, respectively.

Generally, the taste panel results revealed that the harvest date had little influence on the quality of the frozen strawberries (Table 3). However, a trend was observed which indicated that the wholeness of the thawed fruit from the second picking was better than the first harvest. "Wholeness" refers to the appearance of the sliced berries with respect to the degree of disintegration. This relationship was found for the majority of the varieties and selections. In this study, Holiday and Md. US 4579 were rated as best in wholeness by the taste panel.

The majority of the strawberries possessed good color and were acceptable by the taste panel. The varieties and selections which were best in color were: Earliglow, Holiday, Honeoye, Md. US 4579, and Md. US 4429. In contrast, Md. US 4386 and Scarlet were considered poor in color by the taste panel.

The flavor evaluation results indicated that Delite, Holiday, Honeoye, and Md. US 4579 were preferred by the taste panel. These strawberries were scored significantly higher than Earliglow, Md. US 4426, and Scarlet. However, the flavor of most of the strawberries was highly acceptable by the panel members.

The texture ratings varied among the strawberries evaluated in this study. Canoga, Holiday, Honeoye, and Md. US 4426 were rated highest by the panelists. Guardian and Md. US 4380 were rated poor because they were extremely soft.

To summarize the taste panel results, the quality of each strawberry variety and selection was assigned to a single quality ranking (Table 4). This classification was based on the sum of the color, flavor, texture, and wholeness scores for both harvest dates (Table 3). The majority of the strawberries were found to be acceptable for freezing. However, a few tended to be superior in quality. They were: Holiday, Honeoye, Md. US 4426, and Md. US 4579.

TABLE 1.—Chemical Composition of Fresh Strawberry Varieties and Selections at Two Harvest Dates, 1980 Season.

Variety or Selection	Harvest Date	pH	Total Acidity* %	Soluble Solids %	Vitamin C mg/100 g
Canoga	6-23	3.49	0.89	5.5	47
	6-30	3.54	0.73	5.3	40
Delite	6-19	3.38	0.89	5.3	44
	6-26	3.28	0.92	5.3	28
Earliglow	6-19	3.32	0.94	6.6	44
	6-26	3.20	0.98	7.1	44
Guardian	6-23	3.30	0.79	5.6	45
	6-30	3.42	0.70	5.7	35
Holiday	6-19	3.25	1.00	4.7	47
	6-26	3.25	0.95	5.5	45
Honeoye	6-19	3.22	1.01	5.2	47
	6-26	3.12	1.02	5.6	40
Md. US 4380	6-19	3.15	1.19	6.5	39
	6-26	3.12	1.17	7.1	25
Md. US 4386	6-23	3.34	1.05	5.8	34
	6-30	3.34	0.93	6.4	35
Md. US 4426	6-23	3.39	0.68	5.8	30
	6-30	3.31	0.61	6.5	34
Md. US 4429	6-23	3.36	0.73	5.6	32
	6-30	3.28	0.63	6.6	34
Md. US 4579	6-23	3.34	0.76	5.3	44
	6-30	3.31	0.73	5.5	41
Scarlet	6-19	3.44	0.71	5.7	47
	6-26	3.32	0.76	6.1	40
Scott	6-19	3.30	1.06	5.5	39
	6-26	3.19	1.08	5.4	22

*Calculated as citric acid.

TABLE 2.—Chemical Composition of Frozen Strawberry Varieties and Selections at Two Harvest Dates, 1980 Season.

Variety or Selection	Harvest Date	pH	Total Acidity* %	Soluble Solids %	Vitamin C mg/100 g
Canoga	6-23	3.55	0.73	35.2	33
	6-30	3.65	0.70	28.5	41
Delite	6-19	3.52	0.68	27.8	34
	6-26	3.55	0.69	37.7	25
Earliglow	6-19	3.48	0.72	28.2	45
	6-26	3.53	0.72	40.2	41
Guardian	6-23	3.48	0.72	25.4	38
	6-30	3.62	0.56	36.4	28
Holiday	6-19	3.41	0.85	27.6	44
	6-26	3.42	0.93	21.5	43
Honeoye	6-19	3.44	0.86	28.4	41
	6-26	3.49	0.69	34.7	37
Md. US 4380	6-19	3.44	0.84	27.8	38
	6-26	3.42	0.91	28.4	24
Md. US 4386	6-23	3.46	0.76	32.0	33
	6-30	3.44	0.80	31.5	25
Md. US 4426	6-23	3.56	0.64	24.3	29
	6-30	3.62	0.59	31.2	27
Md. US 4429	6-23	3.52	0.59	21.8	27
	6-30	3.63	0.55	36.3	29
Md. US 4579	6-23	3.56	0.54	29.4	25
	6-30	3.51	0.59	26.9	25
Scarlet	6-19	3.57	0.55	24.2	44
	6-26	3.58	0.62	33.8	35
Scott	6-19	3.64	0.68	26.8	31
	6-26	3.50	0.92	24.7	19

*Calculated as citric acid.

TABLE 3.—Results of the Sensory Evaluation of Several Strawberry Varieties and Selections for Freezing at Two Harvest Dates, Based on Quality of Thawed Product, 1980 Season.

Variety or Selection	Harvest Date	Quality Characteristics*				Overall Quality†
		Color	Flavor	Texture	Wholeness	
Canoga	6-23	2.4	2.8	3.0	3.0	11.2
	6-30	2.0	2.1	2.9	2.9	9.9
Delite	6-19	2.2	3.1	2.9	3.1	11.3
	6-26	2.5	2.4	1.9	2.6	9.4
Earliglow	6-19	3.1	2.1	2.6	3.0	10.8
	6-26	3.0	2.5	2.6	2.9	11.0
Guardian	6-23	2.1	2.3	1.7	2.4	8.5
	6-30	2.9	2.5	1.4	2.3	9.1
Holiday	6-19	3.3	3.0	3.2	3.7	13.2
	6-26	3.6	3.1	3.4	3.6	13.7
Honeoye	6-19	4.0	3.2	3.0	3.6	13.8
	6-26	3.5	2.7	2.6	3.1	11.9
Md. US 4380	6-19	2.5	2.5	2.4	2.7	10.1
	6-26	2.8	2.8	1.9	2.5	10.0
Md. US 4386	6-23	2.0	3.2	3.0	3.0	11.2
	6-30	2.0	2.1	2.5	2.7	9.3
Md. US 4426	6-23	3.2	2.6	3.1	3.6	12.5
	6-30	3.0	2.0	3.1	3.1	11.7
Md. US 4429	6-23	2.4	2.3	3.0	3.5	11.2
	6-30	3.1	2.8	2.2	3.2	11.3
Md. US 4579	6-23	2.9	2.5	2.5	3.9	11.8
	6-30	3.1	3.1	3.0	3.2	12.4
Scarlet	6-19	1.1	2.0	2.1	2.1	7.3
	6-26	1.8	2.2	2.5	3.0	9.6
Scott	6-19	2.5	2.5	2.5	3.0	10.5
	6-26	2.8	2.7	2.7	2.8	11.0

*Preference scale of 1 through 5 (5 being the most acceptable).
†Sum of color, flavor, texture, and wholeness.

TABLE 4.—Classification of Several Strawberry Varieties and Selections for Freezing Quality, 1980 Season.

Quality Ranking*			
Very Good	Very Good to Good	Good to Fair	Fair
Holiday	Earliglow	Canoga	Guardian
Honeoye	Md. US 4429	Delite	Scarlet
Md. US 4426	Scott	Md. US 4380	
Md. US 4579		Md. US 4386	

*Sum of color, flavor, texture, and wholeness scores for both harvest dates (Table 3): very good > 24.2; very good to good, 24.1 to 21.5; good to fair, 21.4 to 20.1; fair < 17.6.

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Pomerene Forest Laboratory, Coshocton County: 227 acres

Southern Branch, Ripley, Brown County: 275 acres

Vegetable Crops Branch, Fremont, Sandusky County: 105 acres

Western Branch, South Charleston, Clark County: 428 acres